Chapter 10

Binoscopes of the Third Kind

What are "binoscopes of the third kind"? Binoscopes for the most part can be either commercial (first kind) or homemade (second kind). But there are a lot of binoscopes out there in telescope land that are both. The author likes to call these kinds of binoscopes simply "binoscopes of the third kind." They can have a varied combination of parts or accessories that are both homemade and commercial and still can be a lot of fun to build and use for astronomy. These types of binoscopes can have mounts that are commercial but have homemade optical systems. Or they can have mounts that are homemade but carry commercial optical tube assemblies. Either way, "binoscopes of the third kind" can have a little of both built in the way of commercial and homemade qualities (see Fig. 10.13). For the most part, it doesn't have to be necessarily a binoscope either. It can be anything associated with and/or used for binoculars or binocular astronomy in general. A new binoscope ATM astroterm been has probably not been "coined" here. And even if for some reason it never catches on as a new "household word," the author won't be too disappointed.

The following ATM projects are just a few interesting examples of what "binoscopes of the third kind" could look like. Each of the articles is told by the individuals in their own words giving the reader some great insight on how these particular "binoscopes of the third kind" were designed and made.

Eight-Inch Binocular Telescope

By the members of the Wabash Valley Astronomical Society

The *Wabash Valley Astronomical Society* in Lafayette, Indiana, started its discussions for a new project in the fall of 1998. After months of discussions and presentations, we

N. Butler, *Building and Using Binoscopes*, The Patrick Moore Practical Astronomy Series, DOI 10.1007/978-3-319-46789-4_10

Fig. 10.1 Eight-inch binocular telescope (Image credit: Wabash Valley Astronomical Society)

decided to build an 8-in. binocular telescope. Three major issues of design came up: The first was portability. Two 8″ optical tube assemblies mounted permanently together would be quite bulky. Using two separate tubes that would be separated between uses and reattached for use might make the alignment problem (second issue) more difficult. We decided to make the tubes in sections with only the rear parts permanently attached in a box frame (Figs. 10.1 and 10.2).

The secondary cage construction was first. The upper section includes a truss tube section to increase portability and decrease the needed storage space. The second issue was alignment: With a binocular scope, there has to be a way to adjust the distance between the eyepieces. The individual scopes are Newtonian reflectors, so when the light cone comes out of the side of the tube, it is bounced off a star diagonal (the "tertiary") so that the light cones and eyepieces are parallel for viewing. With this setup, the easiest way to vary the interocular distance is to use a focuser at the normal Newtonian position to vary the distance from the telescope tube to the tertiary and eyepiece. The problem with that is that it changes the distance from the primary mirror to the eyepiece, so it changes the focus view from the bottom, showing the reflection of the built-in Barlow in the 2.14″ secondary. The secondary holder was made from a piece of black PVC pipe. Jim machined the helical focuser from two pieces of spare aluminum. The inner piece threads into the diagonal where the original eyepiece holder tube was. The inner piece is threaded on the outside. The outer piece then threads onto the inner piece for fine focusing. The upper inside of the outer piece is not threaded, rather the original eyepiece

Fig. 10.2 Completed optical tube assembly (Image credit: Wabash Valley Astronomical Society)

holder slides into it for coarse focusing. The outer piece has a knurled grip ring. Next, the truss assembly was constructed. Another focuser is placed after the tertiary and holds the eyepiece. We wanted to build a scope that could be used at public events, and it has been our experience that the general public is often very timid about touching the controls on a scope, so having to adjust the first two focusers and then make a significant change with the other two focusers may be too much "fussing" for the general public. Another option is to change the interocular distance by moving one or both telescope tubes. The difficulty with this is that with the magnification, the tubes need to maintain their alignment to within about 1 arc minute (at high power and especially in the vertical direction) for the eyes and brain to combine the two images into one. This is difficult to do, given the size and weight of the full tubes. Several methods to do this have been tried by other people, and it is generally regarded as one of the most difficult parts of building such a telescope. We ultimately decided to suspend the lower sections of the tubes from pivots so the tubes would swing out away from each other to the needed interocular distance (much like conventional binoculars, except that each tube will have its own pivot) (Fig. 10.3a, b).

The third issue involved optics: As mentioned above, an extra diagonal is needed to aim the light cones and eyepieces in a parallel direction. This means more of the light path is past the secondary, so a larger secondary is required, and that will degrade the image. A possible cure for this is to install a Barlow lens in the side of

Fig. 10.3 Completed optical tube assembly (Image credit: Wabash Valley Astronomical Society)

the tube where the light cone exits the tube. This stretches out the remainder of the cone so that a smaller secondary can be placed farther from the primary and still achieve focus at the eyepiece. The drawback is that the scope operates at a high focal ratio, which means higher magnification, a correspondingly smaller field of view, and tighter alignment tolerance. In fact, since the light path bounces through the tertiary star diagonal before going to the eyepiece, a standard 2× Barlow will operate at about 3×. We used a "shorty" Barlow, with the Barlow tube itself acting as the extension tube between the side of the main tube and the tertiary. In our Barlow, the cell holding the Barlow lens itself unscrews from the tube so it can be removed for low power viewing. There may be a bit of vignetting in this case since in choosing the secondary size, we compromised between the two options, but leaned toward the smaller size, leaving open the possibility of getting a larger second set of secondaries later for better low power viewing. The lower tube sections will have two sets of mounting holes for the primary mirror cells since the mirrors will have to be moved forward if the Barlow is not used. It is a common knowledge that using two eyes allows for easier viewing and usually provides a better view, but after reading about the extreme difficulty of the alignment problem, you may be wondering why we didn't just start with a single primary with twice the surface area but use a binoviewer. After all, a larger primary is theoretically capable of producing higher resolution, right? There are several reasons why we didn't take that route: first, the cheapest binoviewers cost about as much as our entire budget for this project. Second, while a larger primary would achieve better resolution under perfect conditions, conditions are rarely good enough to get better resolution than an 8″ mirror provides, and a larger mirror will actually be more affected by atmospheric turbulence on bad nights. Also (and not often recognized), since the two mirrors will be looking through different air masses, they will show two slightly different images, depending on how each is affected by the turbulence. When the brain gets two views of the same object, it is remarkably good at concentrating on the sharper image. Thus, a true binocular scope provides good views almost twice as often as a single tube scope. Finally, another reason we made

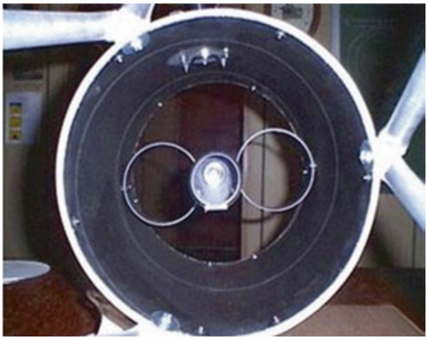

Fig. 10.4 Completed optical tube assembly (Image credit: Wabash Valley Astronomical Society)

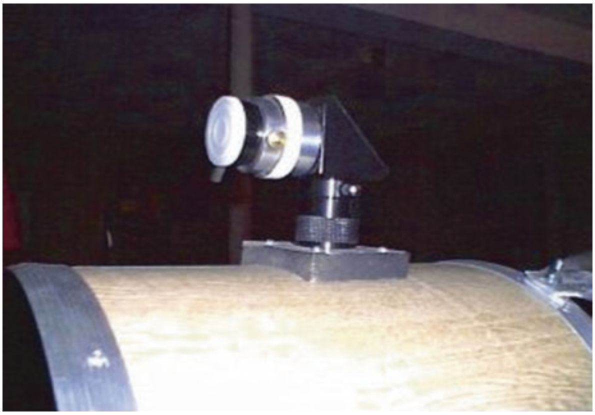

Fig. 10.5 Optical tube with Barlow attached (Image credit: Wabash Valley Astronomical Society)

this particular type of scope (and not some other type of scope altogether) was that Jim Sattler had two 8″ mirror blanks to donate to the project. Curious about how we built this? Tour the construction (Figs. 10.4 and 10.5).

The first step was to build the box frame to hold the two tubes. Jim Mettler took charge of this part. The frame was made from 3/4″ square aluminum tube (1/8″ wall thickness) held together with machined fittings press-fit into the ends. The fittings were made very slightly oversized, with the corners of the square pegs rounded to avoid splitting the square tubes. After a few hours of cutting aluminum tube lengths and pressing the fittings into them, the basic frame took shape. Then, we added two 1/8″ aluminum sheet plates to hold the altitude bearing, and since one section of the frame has to be left out so that the frame can be moved in altitude when on the pier, more 1/8″ aluminum sheet was used as a gusset in the back to keep the two sides from sagging toward each other (Figs. 10.6 and 10.7).

After the frame was complete, the mount bearing was created. The following parts make up the bearings (Fig. 10.8).

Fig. 10.6 The fitting being pressed into a tube section (Image credit: Wabash Valley Astronomical Society)

Fig. 10.7 A close-up of a corner fitting about to be pressed into a tube section (Image credit: Wabash Valley Astronomical Society)

At the left is a section of 4″ PVC pipe that slides into the pier. Two snug wooden spacer rings made by George Gourko provide a tight fit (only one is shown—the other is already in the pier). At the top of the pipe is a threaded adapter. In the center of the picture is a 4″ PVC “T” sliced in half, that forms the heart of the mount (Jim Sattler’s idea) (Figs. 10.9 and 10.10).

Fig. 10.8 Close-up view of the rectangular tube frame section (Image credit: Wabash Valley Astronomical Society)

Fig. 10.9 The 4-in. PVC pipe section on the left that slides into the pier (Image credit: Wabash Valley Astronomical Society)

Fig. 10.10 PVC section sliced in half "T" that performs the heart of the mount (Image credit: Wabash Valley Astronomical Society)

In the center of the picture is a 4″ PVC "T," sliced in half, that forms the heart of the mount (Jim Sattler's idea). The third ("stem of the T") opening is threaded and screws on top of the pipe to form the azimuth bearing. Heavy grease is applied for smooth movement. A 4″ diameter aluminum tube that will be cradled on the top of the "T" to form the altitude bearing is shown in Fig. 8.13. This tube will be mounted in the box frame between the optical tubes, so it will be sort of an "inside out" version of a standard Dob mount (Figs. 10.11 and 10.12).

For the altitude bearing, wooden disks made by George Gourko were pressed into the ends of the 4″ diameter aluminum tube. These were drilled off-center (left) to allow a vertical adjustment for balancing the scope. Teflon pads were added to the T (Fig. 10.11) and a stop was added to make sure the mount wasn't accidently "unscrewed." But the off-center holes mean there will be some torque on the tube, so sandpaper disks were glued to the disks (right) for better friction when the bearing is mounted between the side plates in the box frame. To allow for horizontal adjustments, slots rather than holes were cut in the side plates for mounting the bearing (Figs. 10.12 and 10.13).

The pier is from a 16″ Meade Starfinder Newtonian. The pier is on semi-permanent loan from the Prairie Grass Observatory.

Wabash Valley Astronomical Society

Adapted from "Eight Inch Binocular Telescope" with permission from Wabash Valley Astronomical Society (http://www.stargazing.net)

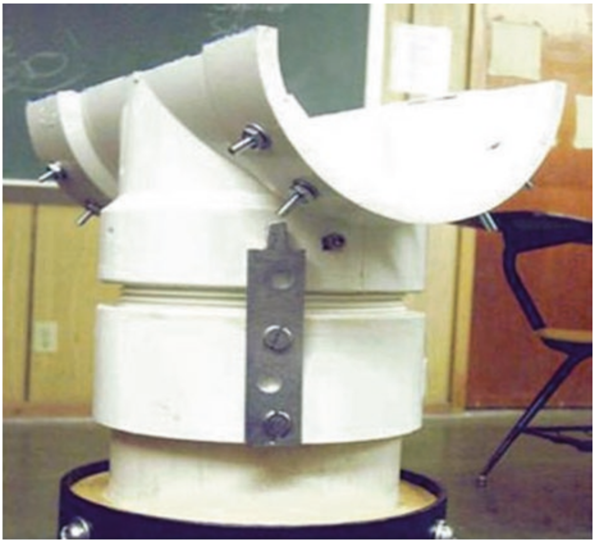

Fig. 10.11 PVC section sliced in half "T" that performs the heart of the mount (Image credit: Wabash Valley Astronomical Society)

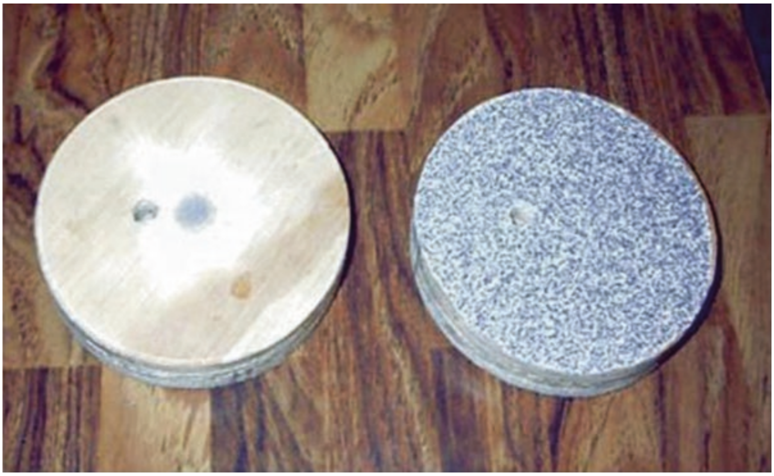

Fig. 10.12 Teflon pads were added to the "T" along with a stop (Image credit: Wabash Valley Astronomical Society)

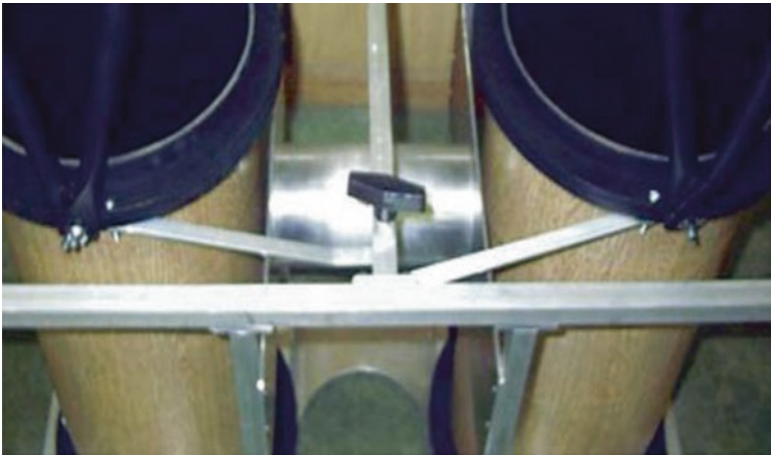

Fig. 10.13 The handle in the middle section rotates an arm that makes the two optical tubes swing apart via a pivot point. (Image credit: Wabash Valley Astronomical Society)

Short Notes on Asymmetric Binocular Telescopes

By Dr. Alex Tat-Sang Choy (Hong Kong)

I've always dreamed of having a pair of big binocular telescopes since teenage. In 2002–2003, I built a pair of asymmetric binocular telescopes with what I believed to be the simplest design, using very simple tools. This design gives essentially the same optical quality for each telescope tube and is very suitable for amateur ATM. Recently, I noticed a new Cloudy Nights article by Bill Zmek showing a binocular telescope he intended to build with a design he discovered independently. Since I already built one and used it for a long time, I think I should share some thought so anyone who tries to build binoculars with this design will have the benefit of my experience (Fig. 10.14).

If we are given a pair of 40-mm refractors with diagonals, it would take 5 min to build simple binoculars. Simply find a piece of wood, drill a few holes, and secure the refractors in parallel and we're set. The separation of the two eyepiece's center would have to be the interocular distance of our eyes, which is usually between 5 and 8 cm. However, if we're given a pair of larger refractors, say 120 mm in diameters, such simple design would not work. The asymmetric binoculars are a design to solve this problem. (Bill Zmek has drawn nice figures and explained the principle clearly, so I would not repeat here.)

Fig. 10.14 The 8-in. binocular telescope pier with altitude bearing attached (Image credit: Wabash Valley Astronomical Society)

When building binoculars with this design, the following details may be helpful:

1. Let me call the uncut OTA as tube A and the cut OTA as tube B. Since tube B is cut and rejoined at 90°, in order to retain the original optical quality, it is crucial to have a mechanism to align the optical axis of tube B or else the optical quality of the final product will not justify the hard work of making the binoculars. I learned this the hard way (Fig. 10.15).
2. There must be mechanism for the alignment of optical axis of A and B. Unlike regular binoculars, which goes up to as much as 40× magnifications, these binocular telescopes are expected to work at 100× or 200×. At these powers, a minute off in optical axis will result in 1–2° off in the visual image. Although the human eyes/brain can adjust for minor mismatch in images between the two eyes, it may only take a few minutes of observation to make one tired and stressed. The result is reducing productivity and enjoyment (Fig. 10.16).

   The design shown in Fig. 10.16 does not have alignment mechanism between tube A and B, giving me a lot of trouble in actual observation. I have since reworked the mounting plate between A and B and added an x-y fine adjustment for tube B, which makes my observation night a lot more enjoyable.
3. Rigidity of the assembly is important. The distribution of weight of this pair of binoculars is strange, parts holding the OTAs in place must be strong, and vibration dampening may be necessary.

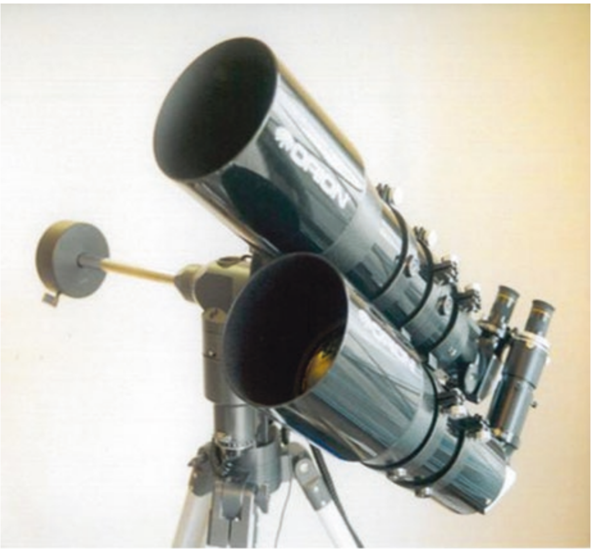

Fig. 10.15 The asymmetric 120-mm binocular telescope—front view (Image credit: Dr. Alex Tat-Sang Choy)

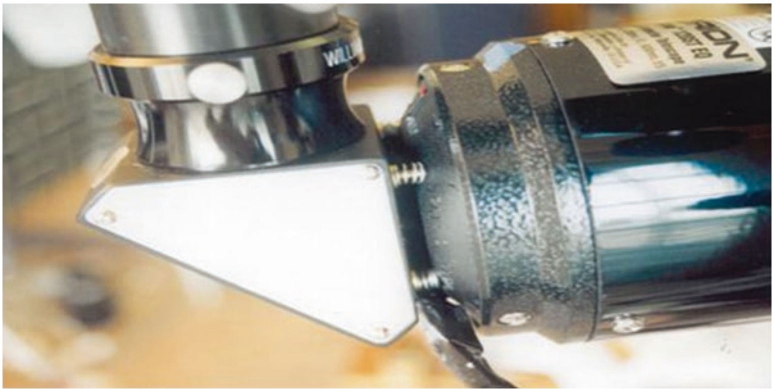

Fig. 10.16 The asymmetric 120-mm binocular telescope—diagonal view (Image credit: Dr. Alex Tat-Sang Choy)

4. Center of gravity is important. The center of gravity for this binocular telescope is somewhere strangely placed, both in the up/down and front/back direction. The binocular telescope itself is very heavy and has large moment of inertia; slight mismatch between the mount axis and the center of gravity of the assembly can make the scope hard to use.
5. This is a heavy scope and requires stronger mount. Fortunately, I had a handy LXD55. My LXD55′s "polar" axis can be adjusted to point upward, and the

Fig. 10.17 The asymmetric 120-mm binocular telescope—front rear view (Image credit: Dr. Alex Tat-Sang Choy)

controller can be made to believe it is an LX90. My binoculars on the azimuth LXD55 is usable, although not great. But a 120-mm GOTO binoculars can draw some attention. In any case, strong mount is important (Fig. 10.17).

1. There are three 90° binoculars designs I know of, and they have their disadvantages:
   (a) *Matsumoto design*. It uses two mirrors per tube and gives erect images, which is great for wide angle panning in star fields. I thought it is a brilliant design, but it is probably not easy to build and not cheap to buy.
   (b) *Asymmetric design*. Mirror image could be hard to get used to for scanning and panning in the star field. I used only a few days to build the prototype, but a lot more effort to improve upon it. I had only simple electric drills and saws, if I could build one, it's not difficult.
   (c) *Three mirrors per tube design*. Its interocular distance is adjustable, but buying six mirrors and aligning them could be not favorable for ATMs. The multiple reflection also places strong requirement on the quality of mirrors.
2. Interocular distance adjustment is overrated. I had great trouble finding a simple, strong, and low cost solution for interocular distance adjustment. In the end, I decided to build first, think later. My binoculars have a fixed interocular distance of 5.5 cm. I have since shown them to some members of the Columbus Astronomy Society and even once to the public at the Perkin's Observatory; to my surprise, only about 1 in 10 people complaint about not able to merge the two images. Large percentage of the public grasped at the sight of a 23× moon. (And since they never used my telescope for long observations, I do not know if they would

still feel comfortable in the long run.) Therefore, from an ATM's point of view, NOT building the interocular distance adjustment could be a decision that saves more than 40% of the effort, a nice trade-off in my opinion.

3. The viewing. While I was still in the USA, where dark skies were accessible, this pair of binoculars gave me some of the most memorable views. In a good night using a pair of mid-priced 30-mm 80° eyepieces, I could view the entire M31 filling up most of the 80° apparent field of view, while at the same time clearly see the dust lane and the companions. M42 was 3D like. The whole Veil Nebula could be seen together without any filter. And the Milky Way was simply stunning. Unfortunately, the 120-mm achromat was not good for planet observation. Despite that, the most touching view I had was during a total lunar eclipse, at 23×, when some faint cloud passed in front of the pale orange moon, the color and perception of 3D was breathtaking.

The refractive binocular telescope brings a different dimension of enjoyment to star observing due to its great image clarity and contrast. The asymmetric design is probably the easiest to build for ATMs and in my opinion, worthy of all the hard work and resources.

Dr. Alex Tat-Sang Choy

Adapted from a Cloudy Nights story "Short Notes on Asymmetric Binocular Telescopes" with permission from Dr. Alex Tat-Sang Choy (Hong Kong)/Astronomics (www.astronomics.com)

Easy-to-Build Binocular Chair

By Greg Walton (MPAS/ASV Member)

Most binos are designed to look at the horizon (Terrestrial) and very few come with 45° or 90° eyepieces and these are very costly. So I had to come up with some way of holding the binos and be able to look through them at the zenith (straight up). First, I tried the camera tripod but these were too low and hard to aim at the object, and I would end up with a bad neck trying to look through them. The second thing I tried was the trick of looking down into a mirror laid on a table, which was much easier on the neck, but my arms quickly became tired. Also the sky was upside down, and all the stars were double stars because I used an ordinary mirror that was aluminized on the back instead of the front. The third thing I tried was to lay on my back and rest the binos on my head; this worked best so far, until I wanted to look at an object close to the horizon.

I then thought I should get a reclinable car seat and put it on a swivel base and then motorize it all and mount the binos on a bracket in front of my nose. With a push of a button, I could move around the sky. But it all looked like too much work (Fig. 10.18).

Then I came across a metal-framed reclinable chair in an opportunity shop for $30 and it had a swivel base. I thought to myself, that's it, I can make this work. I would

Fig. 10.18 The asymmetric 120-mm binocular telescope—rear view (Image credit: Dr. Alex Tat-Sang Choy)

not need electric motors; my legs can do the job of steering the chair. So I dragged it home and fitted a bracket to hold a pair of 80-mm binos. I also added a 300-mm long spring with a diameter of 25 mm at the rear to balance the weight of the binos. Then I found when I leaned all the way back, I could not lean forward again, because of the extra weight of the binos. So I added a strong spring under the chair to help me lean forward (Fig. 10.18b). I added 4 knobs to the mounting bracket, so I could adjust the angle of the binos quickly. I found as I lent back in the chair, I tended to slipped down lower in the chair. I had to compensate by changing the angle of the binos, so when the chair is all the way back, the binos are looking straight up at the zenith (Fig. 10.18c). The chair is light weight in construction, so it's easy to move around or take to a dark sky site. I thought about adding wheels, maybe when I'm 90.

I have also added a pair of 100-mm binos to one of these chairs and have spent many hours at a time looking at the sky with no ill effects. My only complaint is that everybody who comes along wants to test the chair, and I can't get them out. I have found these types of chairs are quite easy to come by at $50 and have bought 5 in the last year, so I am sure there must be a lot around.

I used 25-mm U bolts to attach the balance bars to the steel frame, at the top of the back rest. By adjusting the tension on the nuts, I can get the right amount of friction when adjusting to the desired angle. I bent the balance bars to a slight S shape, to make it easy to get into and out of the chair. The balance bars are made from 22-mm round steel tube 1.5-mm wall thick and are easily bent or flattened in a vice. I am sure anyone could make this chair and improve upon it.

By Greg Walton

Adapted from "Easy to Build Binocular Chair" with permission from Greg Walton—Mornington Peninsula Astronomical Society/ASV member, Australia (http://www.mpas.asn.au)

EZ BINOC Mount™ KIT

As with almost all of our products, this mount was originally developed to meet the individual's rather demanding personal needs. Its weatherproof and virtually indestructable, so that it can be left outside for instant use. Its portable - it can also be moved around the yard to various locations or broken down for transport. Its solid and stable. It is a 5 axis design that allows viewing from any position. It takes no more than 10 seconds to mount or dismount the binoculars. The mount's inexpensive, and it will accommodate almost any size binocular from 7X50 to 25X100. And some like to travel. While originally designed as a fixed in place mount, it is nice to be able to get away to a darker sky. By unscrewing the three legs, the counterbalance arm, and one of the two short grip arms the mount collapses into a relatively compact 41-inch x 7-inch x 7-inch package. You don't NEED to wrench these parts tight to reassemble at a dark site, but its good to keep a small 12-inch pipe wrench handy as the mount isn't rigid unless at least the legs are tight.

All parts that required machining, welding, drilling or thread tapping. Plus parts that were carefully chosen for this mount and are not commonly available elsewhere. Except for the modified pipe fittings, all metal parts are stainless steel. At final assembly you configure the mount for either a vertical post type mount (typical of 25X100 and larger binoculars) or a horizontal screw mount on pair of 15X70s for example. The kit contains all mounting screws and other hardware for mounting your binocular in either configuration (Fig. 10. 19).

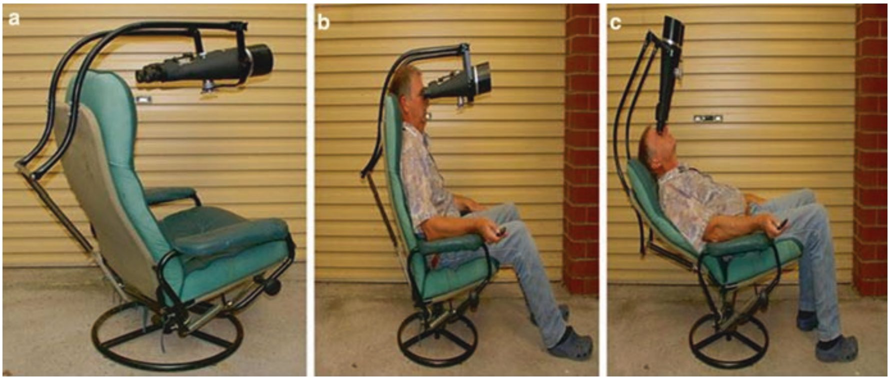

Fig. 10.19 Three photos of Greg Walton's easy to build binocular chair (Image credit: Greg Walton)

You can unscrew the 3 legs and the counterweight arm. At this point the mount becomes very compact - less than 4-feet by 1-foot by 1-foot and will fit almost anywhere. - Peterson Engineering.

Adapted with permission from the website: www.petersonengineering.com.

Dual C-11 Celestron and Borg Binocular Binoscope

Binoscopes

By Jochen Schell

At this website (www.binoscopes.de) I want to tell you about my experiences with binoscopes.

After being an amateur astronomer for over 25 years having owned several small and big telescopes as well as many binoculars I felt that I am most impressed by observing with two eyes using binoculars.

So I had the wish for even more binocular aperture and tried out several big binoculars in the 80- and 100 mm range but unfortunately all have been very disappointing…

I was close to give up this idea when I decided to make a last try in building a binoscope using two Borg 125 mm ED APO refractors and Tatsuro Matsumoto's EMS systems.

The result and experiences with this instrument were way better than expected and motivated by this result I wanted even more.

I thought about building a double dobson but gave up this idea quite soon because of the size, weight and unfriendly usage of these huge instruments.

Finally I ended up with Schmidt-Cassegrain telescopes, also because I already owned a C8 and a C11 and only needed to find matching second tubes for them.

The advantage of these SCT is there big aperture while still being quite small and lightweight instruments.

Also the usage is quite similar to a refractor by looking into them from the back and the possibility to use the Matsumoto EMS

I will talk about my binoscopes, how I did build them and the theories behind them at the following subsites:

Thoughts, theories and experiences about binoscopes
The Erecting Mirror Systems by Tatsuro Matsumoto
My Borg 125 mm ED APO binoscope
My Celestron C8 binoscope
My Celestron C11 binoscope
Building a binoscope

Fig. 10.20 Two photos of the EZ Gazer binocular chair (Image credit: AstroGizmos)

Jochen Schell—www.binoscopes.de (Figs. 10.20, 10.21, 10.22, 10.23, 10.24, 10.25, 10.26, and 10.27).

The genius EMS systems invented and produced by Tatsuro Matsumoto in Japan are a central part of building binoscopes. EMS stands for Erecting Mirror System and these systems are available in varying sizes for different telescope projects. Figure 10.28 displays the model EMS-UXL, which I am using for my binoscopes.

One special detail of this EMS is that they display an upright and right-sided picture, just like binoculars. This makes the orientation of the sky easier to deal with, and these binoscopes can also be used for daylight exploring.

EMS has only two mirrors instead of three. This means that there is less light loss caused by reflections. It also means that light travels a shorter distance compared to the diagonal path with three mirrors and 90Â° reflections. This short light path is important when you are building SCT binoscopes because you can keep the required back focus as low as possible (Fig. 10.29).

Everyone can easily make experiment with a binocular using just one or both eyes to see the huge difference. Firstly, there is the subjective magnification; it is bigger with two eyes than with one eye. You can also see more faint details with two eyes, which are not visible with just one eye.

While looking at the stars, you will see more stars with two eyes than with just one—the ability of collecting light is increased by binocular viewing. Usually, one is talking of a factor 1.4242 or sqrt^2 for the gain of magnification and the ability of light collection. Generally, this factor is right for the increased magnification and for the increased ability to collect light for pinpoint objects like stars. But when we are talking about extended objects, such as nebulae and galaxies with a low

Fig. 10.21 The big Dual Celestrons are mounted and ready for action (Image credit: Jochen Schell—www.binoscopes.de)

brightness of area things are different, we do not only need the big ability to collect light but also contrast. Contrast increases by using two eyes, so such extended objects have an even bigger improvement and the factor is more around 1.5–1.8

In order to discuss contrast, we have to talk about the different types of telescopes. An APO refractor displays higher contrast than a dobsonian and a dobsonian has more contrast than a Schmidt-Cassegrain with its huge central obstruction.

Another factor of binocular addition is the ability of our brain to compensate for bad information coming from one eye. This is very interesting when it comes to poor visibility because the seeing conditions are never the same in front of both telescope tubes. Our brain is able to amplify the good images and to ignore the poor ones.

I did a comparison of different objects with my 12.5″ Portaball dobsonian with a 2″ binoviewer and my Borg 125 mm APO binoscope, as well as with my Celestron C8 Binoscope. Even having the smallest aperture, the Borg 125 mm APO binoscope showed me galaxies and nebulae the best. Although it had a bigger aperture, the C8 binoscope is way behind on observing these objects because of the poorer contrast caused by the huge central obstruction

Fig. 10.22 Another view of the dual C-11's in their splendid Altazimuth mount (Image credit: Jochen Schell—www.binoscopes.de)

For brighter objects like planets or globular clusters, things are changing. Here, the C8 binoscope is able to use its aperture and leaves the 125 mm Borg binoscope behind. The 12.5″ dobsonian is at the poorest ranking for all observed objects. Beside weight, size and uncomfortable usage of a double dobsonian, we can also see another disadvantage caused by the long and twice-reflected light path to the eyepiece. The double Newtonian also needs a big secondary mirror which causes an obstruction in the same range of a Schmidt-Cassegrain. The focal ratio and the exit pupil are advantages of the double dobsonian, but they come at a high price.

Unfortunately, we cannot increase the size of an APO double refractor much bigger than 6″ for technical and financial reasons. And even then, we are talking about focal distances of at least 1000 mm, which are not really usable for wide field observations. As a result, for binoscopes, there is no single or universally better telescope.

Fig. 10.23 The dual C-11's setup at the observing site (Image credit: Jochen Schell—www.binoscopes.de)

I prefer the combination of two binoscopes, a double APO refractor with high contrast and a short focal length for wide fields, as well as a double SCT with a bigger aperture and a longer focal length, mainly for planets and globular clusters.

Jochen Schell

(Adapted from his website "Binoscopes" with permission from Jochen Schell—www.binoscopes.de)

Author's Note:

For those ATMs who have built a binocular telescope before, it must have been a rewarding experience to see its "first light". Building a binocular telescope has its challenges and difficulties, but it's worth building one to see the final results. Building a Schmidt Cassegrain binocular telescope is a true challenge, however,

Fig. 10.24 Jochen used three equally spaced aluminum spacers that were machined to match the radius of the C-8 optical tube assemblies (Image credit: Jochen Schell—www.binoscopes.de)

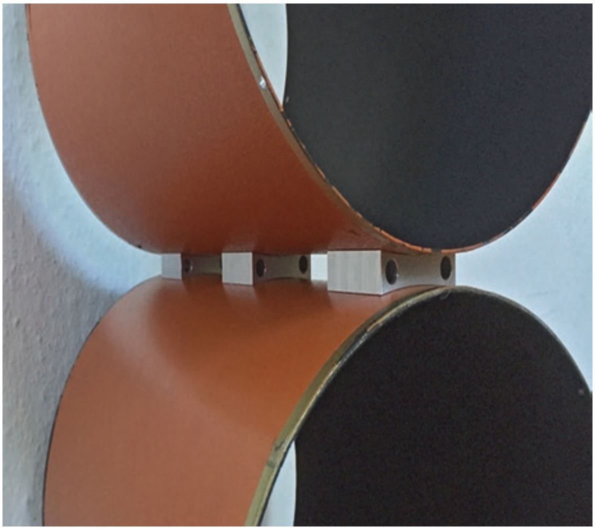

Fig. 10.25 When assembled together notice the close tolerance fit between the aluminum spacers and the C-8 optical tube assemblies (Image credit: Jochen Schell—www.binoscopes.de)

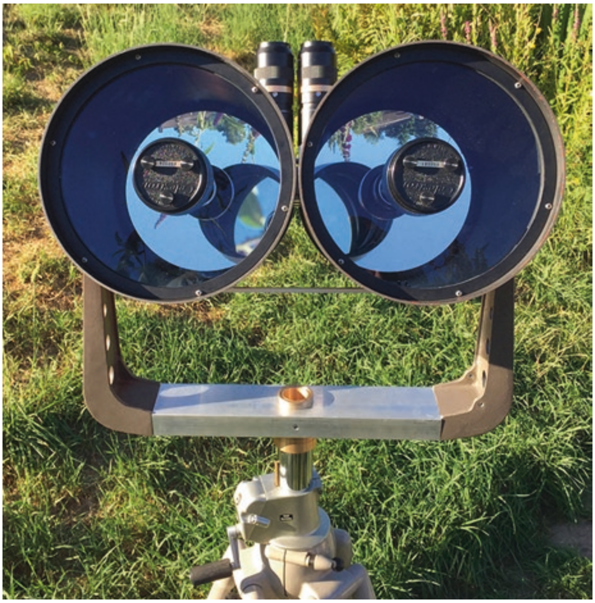

Fig. 10.26 Looking down the double barrel of a dual C-8 photon cannon (Image credit: Jochen Schell—www.binoscopes.de)

Fig. 10.27 Borg 125 mm Binoscope with the 2-inch dual 32 mm eyepiece binoback IPD adjustment system. Notice the interesting vertical dual aluminum knob focusing arrangement on each binoback (Image credit: Jochen Schell—www.binoscopes.de)

Fig. 10.28 Borg 125 mm Binoscope "2nd. edition cover image" with machined adapters and the dual eyepiece binoback IPD adjustment system (Image credit: Jochen Schell—www.binoscopes.de)

Fig. 10.29 The dual eyepiece adapter and the ever popular dual binoback IPD adjustment system (Image credit: Jochen Schell—www.binoscopes.de)

especially if you plan to combine two big Celestrons together into a big Cassegrain binocular telescope on a modified Celestron Altazimuth mount.

Judging by the photos of his excellent, homemade Celestron binocular telescope, Jochen Schell of Germany deserves a lot of credit for being able to successfully combine two C-8 s and a pair of C-11 s together to build his binoscope. His act is a hard one to follow, regardless of how good of an engineer or machinist you are. In a Schmidt Cassegrain binocular project like that you have to know exactly what you're going to do from the start. If not, then the surprises come later. It's no wonder why there are very few homemade Schmidt Cassegrain binocular telescopes.

A Celestron has a primary mirror that is the focusing mechanism in the Celestron Schmidt Cassegrain telescope. It's a beautifully designed optical system, but difficult to make into a binocular telescope. However, once it is in the binoscope, then it tends to become an excellent f/10 binocular telescope. If you decide to invest in two C-8 s to make into your future binocular telescope, prepare to be mechanically challenged. Not only in terms of combining the two the C-8 optical systems, but also modifying the original Altazimuth mounting. One look at the amount of work involved in making a C-8 binocular telescope and you can see why so few are actually made. Nevertheless, it would still be a challenging engineering project if two C-5 s were being used. Obviously, anyone who has the ambition and resources to undertake a Celestron Schmidt Cassegrain binocular telescope project is in for a lot of work regardless of its size. Seeing the results achieved by Jochen Schell after completing his Celestron binocular telescope project should serve as an inspiration for others to attempt the challenging project. There are alternatives to Schell's use of machining aluminum for such an ambitious Celestron binocular telescope project. Wood is a possible option that would be easy to cut and shape into the parts and pieces needed for the same or a similar project.

Building my dual 6 in. f/15 Dall-Kirkham Cassegrain binocular telescope, which I completed in 1980, was a terrific learning experience since I had never attempted any binoscope projects before that. It was a one-of-a-kind binocular telescope and it taught me a lot about building binocular telescopes, Cassegrain optics and optical alignment. Some 36 years later, I still enjoy building my own binocular telescopes, Dobsonians and refractor binoscopes. Someday I would like to build my dream binoscope using a pair of beautifully matched 7-inch Questars Maksutove Cassegrains attached and aligned together on a computerized GOTO mount. that would be my dream binoscope. If you ever had the good fortune to have looked through a 7-inch questar at the moon and planets....then you could imagine what beautiful celestial images two 7-inch questars would render if they were indeed made into a true one-of-a-kind Maksutov Cassegrain binoscope. If by chance there are a couple of interested readers out there have a 7-inch Questar in reasonably good condition and they no longer have any need or interest in them...just give me a hollar. I'll come running.

In all of my astronomical adventures in observing, which date back some 60 plus years, my most memorable ones are of viewing the moon and planets in the mid to late 1950s through scopes of 6–8 in. aperature...Newtonians in particular. An old friend of mine, Jim Starbird of Topeka, owned a beautiful 8 in. f/8 Newtonian that was manufactured by Criterion. That particular telescope, over 60 years ago, I thought was the next best thing to Mt. Palomar. Gotta love those old 1950's Newtonians....an 8-inch Criterian was just one of the many commercial newtonians telescopes that all of us young kids who had an interest in Astronomy would dream about...especially around Christmas time. I alway's hoped Santa would drop one off on Christmas morning....I'm still waiting Santa....ha

The Binochair

By Gary Liming

This is a picture of my binochair after it was completed. The rest of this website is a blog of how it was built and some commentary on using it. At this writing, I've just spent a very pleasant evening with it, and it works great! The large binoculars can be positioned in any direction, and they stay put at the position you leave them. You can cover about 1/5 of the sky before needing to move the chair, so you only have to move the chair five times for a complete sweep of the heavens (Fig. 10.31).

Fig. 10.30 Both Borg OTAs and their accessories are neatly stored in a Rimowa case and ready to travel to dark places and new observing sites. (Image credit: Jochen Schell—www.binoscopes.de)

Fig. 10.31 A photo of Gary Liming's binocular tripod and binochair (Image credit: Gary Liming)

Introduction

This webpage is about making a device to make practical and comfortable use of large binoculars. By "large" I mean the ones I have in mind are 25 × 100 power weighing 10.3 lb. Although that may not sound like much, it's enough to have the following disadvantages:

- Your arms get tired very quickly holding them up to your eyes.
- Holding them up to your eyes renders such a shaky image that it makes them useless and because they are so powerful that the slightest movement—even your heartbeat—makes.
- With that large a weight placed right up against your eyes, a small bump and you get two black eyes quite easily.

Simply stated, they never were meant to be used by just holding them. They do come with a way to place them on top of a standard camera tripod, but those tripods have the problem of being either affordable and rather flimsy or quite expensive for something sturdy enough to hold these. Even if you do get a high-quality tripod, they have three drawbacks.

- It seems the legs of the tripod are always in the way.
- You can't see things directly overhead at all.
- For things high overhead, you neck is bent back constantly, and my neck simply won't handle that anymore.

A common solution among stargazers is to mount a parallelogram type balance beam on a tripod and implement as many degrees of freedom movements as necessary to be able to easily position the binoculars in any orientation and have them counterbalanced. There are many examples of something like this on the net, and I spent some time looking at them.

The design goals of my device are:

- To be used primarily from a lounge type chair. No reason I can't be comfortable while looking up and be able to throw a blanket over me if needed.
- Make the binoculars easily positioned to any spot in the sky.
- Counterbalance the binoculars with just the right amount of friction on the joints so that they seem suspended in front of your eyes—if you let go, they stay put.
- Be able to break it down for easy transport in a regular car.
- Cost is a consideration, which for me means using wood instead of aluminum, so it will probably have a bit of weight, but that I can handle. Besides, wood can look very nice as well.

The actual chair I would like to use, at least to start, is a "zero g" chair I got on sale at Cabela's. It has the advantages of being very comfortable, it is quite easy to lean forward or back with just a slight leg movement, it is fairly portable and lightweight, and best, I already have one! (By the way, they also have a padded version as well as a double seat version that might be great for showing the stars to others (Fig. 10.30).

After looking around the web on various astronomy forums and email groups, I saw pictures of one that I thought would make a good start by Dennis Simmons of Australia. At least initially, I will start with his design until we get to the binocular mount itself.

This device has three main parts, the bottom tripod that provides the azimuth pivot, the parallelogram arm that supports the main up and down weight, and the binocular mount that provides swivel for the binoculars. Accordingly, along the left of this page of the website are the menu selections for the tripod, parallelogram, and mount portions of this build.

Gary Liming

Adapted from "The Bino Chair" with permission from Gary Liming (http://www.liming.org)

The Bolton Group

These binoculars were judged the best at the 2005 Kelling Heath Star Party, the UK's largest and most attended event. This is the first time this award has been made.

I know, I know—we said 8-in. binoculars were the optimum size for both use and transportation but aperture fever has struck again The 12 in. binocular project took nearly 4 years! Gerald got side-tracked into building a new workshop, kitchen, bathroom and driveway. They are similar to the 8-in. except the tubes are 12 sided instead of 6. This was a major project, around 1000 h work, and was completed March 2005. First light was at our dark-sky observing night in March 2005 (Fig. 10.36).

These are just a few minor bits to add in the light of first use but nothing major. The push-pull adjuster for the mirror cell is a new idea by Gerald using a contained (internally and externally) spring. It is adjusted from the top unlike more conventional adjusters. On one telescope they will extend upwards to make them reachable from the eyepieces so final collimation will be a one man job. Unlike the 8-in. binos the eyepieces are not directly between the two telescopes. They are brought out at 45°. This saves a lot of space and makes the binos a lot more compact i.e. not as wide as they might have been.

The finder is a simple red dot type and works excellently. In combination with Pocket Stars on a Pocket PC objects can be quickly located.

Master Optician, Brian Weber Ground and figured both 12-in. (30 cm) f/5 mirrors with their focal lengths differing by less than 1/4-in. (6 mm). The mirrors were made from Suprax blanks (a form of pyrex) and were a bit thicker than desired but by the time both sides were levelle up the thickness was down to 40 mm. As you can see from the ronchigram there is no turned edge! Eagled-eyed might spot a very slight central "hole" but this is of no consequence being in the shadow of the diagonal. The diagonals were also made by Brian and as can be seen by fringes they are smooth and around 1/4 wave—note the slight curve is caused by the camera viewing angle and not the diagonal.

HiLux coated at Orion Optics UK. This enhanced coating claims 97% reflectance—important when there are 6 mirrors! The binos have been our biggest construction job but the effort has been worth it. The following pictures give some idea of the construction. Sorry but there are no drawings available—they just came out of Gerald's head!

The binos were designed to separate into two halves from transport. The bottom cage is attached permanently to the mount and is the heaviest part to lift. Sensibly it requires two people. The top cage is much lighter and is an easy one person lift. The two halves are quickly located and joined with three thumb-screws per tube. These need to be made captive to remove any chance of them falling on the mirror.

Set-up and collimation is also quick and easy. The approximate collimation can be done in daylight with final alignment carried out on an object—usually a star. However, for the Haverthwaite Star Party we couldn't wait and aligned on the crescent moon long before dark. This final tweaking of alignment/collimation is easily done with the push-pull spider adjusters. They keep collimation all night (Fig. 10.32).

Fig. 10.32 A photo of Gary Liming's binochair (Image credit: Gary Liming)

First testing on the very thin crescent moon was breath-taking. During the night we saw all our old favourite deep-sky objects but better than ever before as we were seeing with two eyes! The mount moves effortlessly and is unaffected by the wind.

A common question asked is what about reflections. Sure it looks like the bright ali would produce reflections but of course it doesn't. The necessary parts are blackened such as the spider and inside the focuser but everything else is sparkling ali. There are some black baffles around the mirrors and opposite the focuser.

The binoculars have proved a great success both in use and judged best homemade telescope in the UK's biggest star party at Kelling Heath 2005. They provide a first class tour of the deep-sky, all in the confort of viewing with two eyes and no need for ladders!

215 mm Ultra-Light Binoculars

No sooner were the 12-in. binos finished then Gerald looked around for a new project. The aluminium cut outs from the 12-in. binos were big enough for 8.5 in. ones so the temptation was too great.

The 12-inchers are great for a star party or serious observing but for just carrying out easily for a quick view something lighter is needed. Hence these ultra-lights! The optics are f/6 and all the mirros were made Brian. They are as usual to his very high

Fig. 10.33 Gerald and his almost completed 300 mm binos in his workshop (Image credit: www.deep-sky.co.uk)

standards—if they are not perfect he will not let them out of his workshop! Brian has made many many mirrors of all shapes and sizes. He recently completed a commercial contract for a large test mirror for a company specialising in lasers. To save even more weight the bottom bearing uses a circular rebate in both the upper and lower bearing plates. This is filled with over 100 ball bearings which provides a very wide track for stability plus low weight. It works like a treat. In this new design, the azimuth and altitude axis shafts have been left exposed for the possible option of fitting digital setting circles. I hesitated to show this new idea. Our original 8-in. binos featured crayfords for adjusting the inter-ocular distance. Low and behold when commercial binos appeared a couple of years or so later they too had them! Coincidence? This new solution was not suitable for the 12-inchers as their eyepieces came out at 45°. However, with the smaller size of the 8.5 in. ones we have gone back to inline focusers so some lateral thinking took place. The adjustment only has to be 15 mm maximum—eye separation doesn't vary all that much. Brian devised this method with a single rotating knob (red) to adjust them in synchronisation. The focusing is helical—the black and brass units (Figs. 10.33 and 10.34).

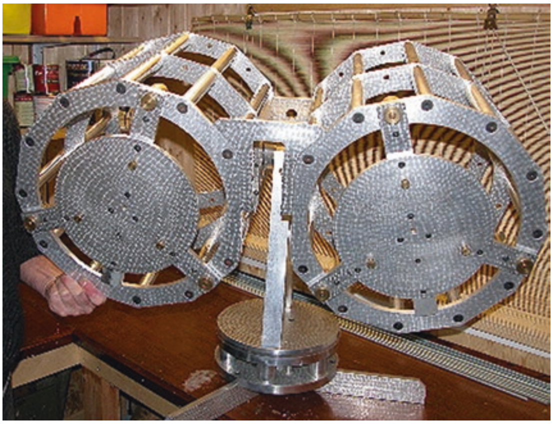

Fig. 10.34 The underside showing the mirror cells (Image credit: www.deep-sky.co.uk)

200 mm Minimalist Binoculars

Our previous light-weight binoculars had weighed in at a very reasonable 65 lbs. But could we go lighter? Gerald had a cunning plan! Going back to basics meant the answer was yes and the these 200 mm Binoculars weigh in at 44 lbs total—an easy one man lift. Yet no stability has been sacrificed and performance will be just as good if not better. To go with these new binos Brian has produced his finest pair of matched mirrors ever. Under autocollimation (double light pass doubling any errors) they exhibit absolutely straight Ronchigrams—no zonal error and no turned edge. We had some great views through them and Luke's adjustable chair made viewing a real pleasure. All design goals have been met, i.e.:

1. Ultra stable
2. Hold collimation
3. Quick inter-ocular adjustment—our simplest yet!
4. Easy one-man assembly
5. Easy one-man move

Note although the side-bearings look like simple Dobsonian bearings they have real bearings—no teflon here. They disassemble into three components for easy transport and storage. What assembly there is, is by thumb-screws—no allen keys required. All the optics were made by Brian i.e. the 2 matching parabolic mirrors, 2 elliptical secondary flat mirrors and 2 rectangular flat tertiary mirrors. The main mirrors are 200 f/5 (1000 mm focal length) and were made from low expansion glass. Their focal lengths are within 4 mm i.e. less than 0.5% difference (Figs. 10.35 and 10.36).

Fig. 10.35 Brian and Gerald at the Haverthwaite Star Party, March 2005 (Image credit: www.deep-sky.co.uk)

Fig. 10.36 The finished 200 mm binoculars (Image credit: www.deep-sky.co.uk)

They were tested using autocollimation with a high quality test flat. In this test the light strikes the mirror under test twice. This is therefore a severe test as any errors present are doubled. In the rochigram they both exhibit straight diffraction lines i.e. no detectable errors or turned edge to the limit of the test. They are certainly better than 1/10 wavelength accuracy probably nearer 1/20 wave.

Author's Note:

It's not often when you come across an excellent group of well designed and splendidly crafted series of binocular telescopes such as the Bolton Group's skeleton tube all-metal binocular telescopes. It's sometimes a rare trait for another active ATM with a healthy ego who can appreciate and applaud the creative talents other ATMs who enjoy the same hobby of telescope making. As an active telescope and binoscope maker myself, I often will become inspired to start another telescope building project when I see a splendid telescope or binoscope that was built by another creative ATM at a local star party or national telescope makers conference. And that's the best part about being an ATM…being able to share your ideas with other ATMs and in doing so, you're helping to advance the science of amateur telescope making…not only on a local level…but internationally too. So let's give three cheers for all of the ATMs out there in the amateur telescope making community who continually surprize us with their creative, innovative and interesting ideas and talents at local star parties and national telescope maker conventions. As an author of telescope and binoscope making books, I'm alway's amazed what the ATMs around the world are creating these days….

Note: The Bolton Group images and website story is presented above with permission from: David Ratledge—The Bolton Group—www.deep-sky.co.uk (Fig. 10.37)

Fig. 10.37 The finished binoculars at Kelling Heath 2012. Gerald is tweaking the collimation. Brian is left and Luke, the new owner, is on the right. We had some great views through them and Luke's adjustable chair made viewing a real pleasure. (Image credit: www.deep-sky.co.uk)

A Comet Discovery?

For those of you who are active comet hunters and are searching the night skies with your binoscope or big binoculars for these elusive small fuzzy snow balls, it's important that you know what to do if you think you've found one you're your telescope. There is a procedure that you can follow in order to confirm your new potential comet discovery.

Author's Note:

A "visual" comet discovery is a remarkable achievement considering the thousands of optical telescopes (amateur or otherwise) around the world that are equipped with the latest CCD camera technology and also looking for comets.

Imagine you're out one night observing with your new big binoculars or your big binocular telescope that you just built, and you were scanning the sky in Ursa Major when you unexpectedly came across a small diffused fuzzy object in your field of view. You immediately become suspicious about the object's small, fuzzy diffused appearance. Because you're suspicious, you reach for your trusty sky atlas and look up the constellation Ursa Major to check for any galaxies, clusters or other objects in that particular area of the constellation that could possibly be mistaken for a comet. After watching the small, fuzzy diffused object in your eyepiece, you think you've detected a slight movement of the object against the background of the stars. Having confirmed using your sky atlas constellation chart that there are no galaxies or globular clusters in the immediate area of your search, you become extremely excited about a possible comet discovery. As you continue watching the object in your field of view, you should check internet Astronomy sources for any known comets that describe their current astronomical locations and visual magnitudes. If you don't find any known comets in the same area from your internet comet source search and you feel confident enough about your potential discovery, then its highly advisable to have it's location confirmed and verified by a professional observatory. After that, you should consider notifying the Central Bureau for Astronomical Telegrams (CBAT) about your possible comet discovery. If you decide to wait another 24 h to see if the small, fuzzy diffused object has moved from its original astronomical location, someone else may spot it and report it. If you are confident in your observation, then notify the CBAT by either telegram or email to cbatiau@eps.harvard.edu along with the following recorded information. CBAT's address: Central Bureau for Astronomical Telegrams, Hoffman Lab 209, Harvard University, 20 Oxford St., Cambridge, MA 02138-2902.

Note:
If for some reason you decide not to notify the Central Bureau for Astronomical Telegrams about your potential comet discovery, someone else probably will.

Example Email or Telegram Template

Dear Central Bureau for Astronomical Telegrams (CBAT),

I would like to report the discovery of a potentially new comet moving slowly across the night sky in the constellation Hercules at the following coordinates with the following physical characteristics:

New Comet Discovery Data:

R.A. (.1”): 17 hr. 30 min.
Dec. (1”): + 42 Deg.
Date: Nov. 1st 2016
Universal Time/GMT (0.001—Time of Day): 10:20:00 GMT—8:20 P.M. P.S.T
I used the following sky atlas to confirm the sighting: Example; Sky and Telescope’s “Pocket Sky Atlas” (See attached chart)
Description of Comet: Small, diffused, round
Estimate of Comet’s Total Magnitude: 10th. Mag
Comet’s Size: 15 min. dia.
Comet’s Diffuseness: Diffused
Possible Tail: No visible tail
Degree of Central Condensation 0–9: 2—Diffused coma with definite brightening towards center
Optical Telescope/Instrument used for Discovery: 10” f/4 Binocular Telescope.
Location of Discovery: Boulevard, California 91905

I am looking forward to your confirmation of my new comet discovery.

Sincerely, the Author

Address
Tel./Cell Phone
Email

P.S. See my attached sky chart for tracking the potential new comet’s 24 h movement through the constellation Hercules.

So is it difficult to discover a new comet? Even after several hundred hours searching the night skies, some comet hunters may never find a new comet while other comet hunters may find one or two new comets in their lifetime. Discovering a single comet during one’s lifetime is a certainly a very worthwhile endeavor and obviously other younger comet hunters will most certainly wish to do the same. However, one comet hunter from Australia deserves naming. With eighteen separate comet discoveries, the late William Bradfield stands out as the legend for all comet hunters to respect and admire (Fig. 10.38).

Brian G. Marsden, the late director emeritus of the IAU’s Central Bureau for Astronomical Telegrams had this to say about William Bradfield: “To discover 18 comets visually is an extraordinary accomplishment in any era, but to do so now is truly remarkable, and I think we can be pretty sure nobody will be able to do it again. And it’s all the more astounding that in no case did he have to share a discovery with some other independent discoverer. More than any other recipient, Bill Bradfield outstandingly deserves the Edgar Wilson Award” (wikipedia.org) (Fig. 10.39).

For more comet discovery info, visit http://www.nightskyhunter.com/index.html and http://www.cbat.eps.harvard.edu/HowToReportDiscovery.html.

When you’re searching for new comets, it really comes down to two or three factors: the longer you search, the better your chances for finding a comet, whether your telescope has a fast focal ratio and a wide field of view, and if it has sufficient light gathering power. However, you also need luck.

Fig. 10.38 They're almost finished with the exception of the un-coated mirrors.…It's almost ready to start pumping photons through those dual eyepieces. (Image credit: www.deep-sky.co.uk)

The use of a big and reasonably fast binocular telescope with a wide field of view will give you the biggest advantage for comet hunting. You can also find comets using a CCD camera on a regular telescope, but when it comes to visually searching for a comet, using two eyes and a big binocular telescope is going to be beneficial. I have talked to several comet hunters and some of them have discovered a comet visually after spending more than a hundred and fifty hours searching the skies. If you're not using a big fast binocular telescope, it may take a lot longer. For inspiration, read the story about Comet Macholz 1985e in Chap. 4.

A Few Closing Thoughts from the Author

Building a telescope, binoscope, or binocular telescope can be in itself a very rewarding hobby and one that can be shared with others. Probably not everyone has the same desire or ambition to build a telescope as an amateur telescope maker has. But like any hobby, whether it be making model airplanes, bird houses, or model ships, one always can take pride in his/her finished product. I've always said that if

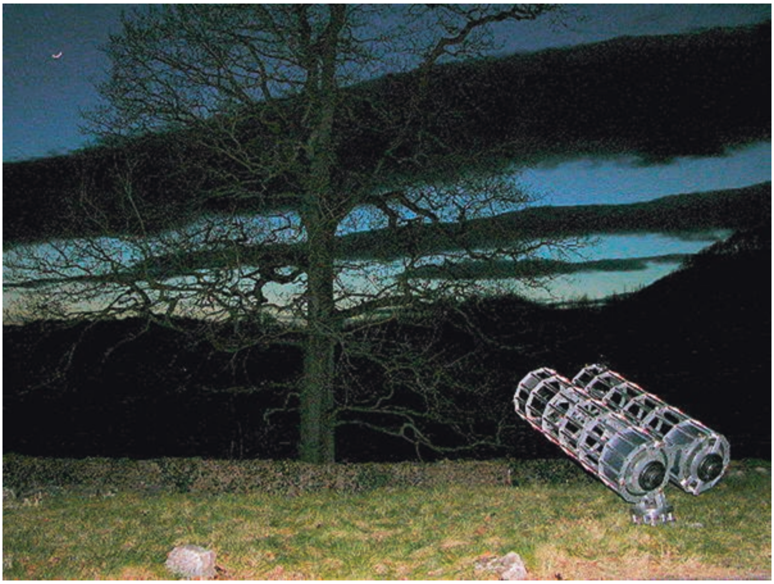

Fig. 10.39 The 300 mm are finished and waiting for dark to show off it's stuff! (Image credit: www.deep-sky.com)

you have a son or daughter that has an avid interest in astronomy, then building a telescope for the family enjoyment can be a joint venture with everyone becoming involved and a very enjoyable one at that. If you're going to build a telescope, before you start your project, then it would be beneficial to research as many ideas on telescope making as you can find. There are many good telescope makers out there who have shared their telescope making projects and experiences on their websites, and that's a good place to start to gather some ideas and information on what kind of telescope you want to build or even buy someday. It would also be a good idea to join a local Astronomy club in your area, where you enjoy a regular monthly meeting and an observing session afterwards. At the same time, try and pick up some good ideas to incorporate into building your own telescope. It's also good to compare notes with other people interested in making telescopes or binoscopes. A good and sturdy telescope design to build with others helping out would be an all-wood 8 in. or 10 in. f/6 Newtonian telescope on a Dobsonian Altazimuth mount. Building it out of wood gives everyone a chance to cut out the pieces, sand them down and finally gluing them together to make the square wooden Newtonian optical tube. Another fun part about building a telescope is painting and designing the exterior (see Fig. 8.35).

Chances are that once you start your telescope or binoscope making project, you already have a good design in mind, the materials needed, and the approximated cost for everything. There are many good deals on the Internet for telescope mirrors and objective lenses. The author has always started his own particular telescope making projects "after" having purchased the optics. They are, for the most part, the most expensive part of your project and the design and construction of your telescope will always center on the physical and optical characteristics of your mirror or objective lens. Obtaining your optics first before you start your project will, in fact, help reinforce your incentive to start building your telescope project. And with your optics always sitting on the table or shelf in front of you will provide the drive for you to finish it in good fashion (Figs. 10.40 and 10.41).

Unless you're from the old school of amateur telescope making, those who enjoy grinding and polishing their own mirrors, it can be a lot of work but at the same time, it can also be a lot of fun to and very rewarding after you've you've finally finished it. If you're going to make a Newtonian telescope, then grinding, figuring, polishing, and testing your own primary mirror can be, for some, the most rewarding part of building your telescope. The same goes for making a refractor telescope and working anxiously to finish it to so you can see its "first light".

There are a lot of mirror grinding kits available on the Internet and many telescope companies that sell mirror blanks and the grinding and polishing materials that go along with them. For example, Willmann-Bell, Inc. has a fine selection of telescope making supplies to choose from. If you want to get friends or family involved in grinding and polishing a telescope mirror, giving them a chance to walk around the barrel, pushing the glass around will make them a lot more excited about your telescope making project. Plus, everyone gets a chance to contribute in building it. The sight of the beautiful gas cloud in Orion, M-42, in the eyepiece of a telescope will certainly get someone "hooked" on Astronomy. Even the sight of the beautiful Andromeda galaxy (M-31) will thrill those who see it for the first time through a telescope. And seeing these beautiful astronomical objects as part of the "first light" through your new homemade telescope will make this a memorable moment.

Thinking back to the early 1980s, the author originally had thoughts about building a big dobsonian binocular telescope. At the time, Coulter Optical Co. was offering a 10.1 in. f/4.5 Odyssey, and with its overall simple design and optical arrangement would have made it relatively simple to join two 10.1 Odyssey dobsonians together in one large "rocker box" Altazimuth mount, thus making it into a big Newtonian binocular telescope. Once combined together in a large "rocker box" Altazimuth mount, and after making some simple mechanical changes, it would have been an excellent example of an early dobsonian binocular telescope. Had it happened at that particular period of time during the early 1980s, the commercial binocular telescope era would have started much earlier. I believe if only "one" had been built back then, Coulter Optical Co. would probably have offered it as a special product and the binocular telescope era would have started much sooner, especially in terms of amateur telescope making.

In the 1980s, Coulter Optical Co. was selling their large dobsonian telescopes at very reasonable prices (10.1 in. f/4.5 Coulter Optical dobsonian sold for $299), but those days are long gone. Today, a big dobsonian 10-in f/4.5 quality mirror can be priced as high as $1500. So even buying one mirror is a major investment. Buying two 10-in f/4.5 quality mirrors to build a big binocular telescope is almost too

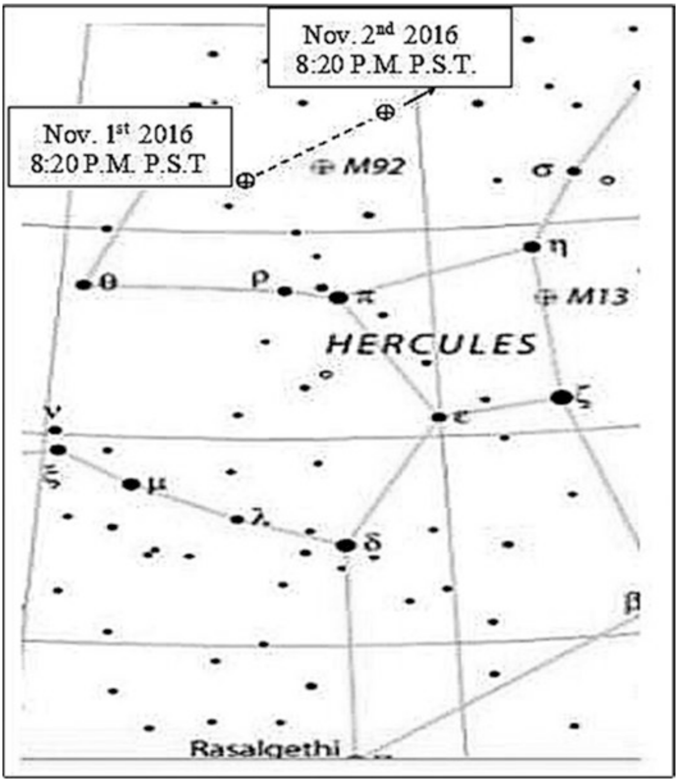

Fig. 10.40 Amateur comet hunter's sky chart showing an example (just for an illustration) of recording a potential new comet's 24-h movement through the constellation Hercules near Messier 92 (Image credit: the Author)

expensive. The cost of secondaries and everything else needed to build a binoscope varies. Binocular telescope and refractor binoscopes have been slow to catch on in the amateur telescope making community because they are very expensive to build.

Even if you only have a humble pair of binoculars or a big dobsonian "light bucket," it really doesn't matter that much at a star party. Everyone is going to get a chance to walk around and check out the great views from all of the telescopes and talk astronomy with all of amateur stargazers and telescope makers at the same time. And that's what makes a star party fun to attend. A star party can offer you an opportunity to check out new telescopes, a variety of different kinds of eyepieces and accessories that you normally might not be able to try out at the telescope store at night if they close before dark. If you buy something online sight unseen, sometimes that can be a disappointing experience too. At least at a star party, you have a chance to compare your telescope and its performance with others and that's a good thing. Your telescope making experience can be shared with others, and once

Fig. 10.41 Comet (Bradfield) from Catus Flat N.E. Colorado, U.S. (Image credit: The Starmon—Wikimedia Commons)

they have the opportunity to look through your own homemade telescope, I'm sure they're going to be impressed.

We have covered several interesting topics on binoscopes and binocular telescopes. All of which are important in their overall design, construction, and optical performance. Obviously some of the topics that are covered in the book are perhaps a little more interesting to read about than others. The important thing is that after reading it, you feel you have learned something valuable about binoscopes and binocular telescopes. In the future, the author aspires to write another book on "The History of Binoscopes" including a chapter in it about building a 3-in. f/10 multiple mirror Newtonian telescope with a Cassegrain style focus that has three primary mirrors (see Fig. 7.29).

As you can probably tell after reading this book, the author is a big proponent of binoscopes. With a 28 incher already having been built in Germany, there is little doubt that an even bigger binocular telescope will be built in the future. As binocular telescopes become more popular with amateur telescope makers and commercial manufacturers, we can expect to see some being built with mirrors exceeding 30 in. or larger in diameter. But in the meantime, still waiting in wings is the multiple mirror telescopes with three or more primary mirrors waiting to evolve into their own special place in telescope making history. From a historical perspective, not much one can find about them, either on the Internet or in telescope making books. However, the concept of using three mirrors to gather light from a single celestial object and focus it into an image that projects three times or more times the light gathering power of a single aperture sounds rather appealing, especially to someone who enjoys the stunning images through a big binocular telescope. One can imagine the stunning view through a multiple mirror with three primary mirrors “pumping” photons into the observer’s eye. That is something to really look forward to in the future as amateur telescope makers start to experiment more and more with multiple mirror telescope designs.

What can we expect to see in the next generation of binocular telescopes and refractor binoscopes? Considering the fact that aperture is everything when it comes to observing celestial objects, we’re probably going to see some monster binocular telescopes that are being built by amateur telescope makers from around the globe. If someone happens to make a matching pair of 30 or 40-in. f/4.5 primary mirrors, then it’s likely that a 30 or 40 in. binocular telescope will be built soon thereafter. In terms of big refractor binoscopes, there is already a big 10-in. APO refractor binoscope that has been made in Japan and an equally impressive 12-in. APO refractor binoscope somewhere in China.

With the increased global popularity of the amateur astronomy community using binoscopes and binocular telescopes over the past 5 or 10 years, more and more ATMs are building their own big binoscopes these days, and more binoscopes are being sold commercially too. Most of us can appreciate the wonderful views that only a big binocular telescope or refractor binoscope can provide. Perhaps a big binoscope or binocular telescope is not for everyone, but everyone can certainly enjoy the views they offer of the starry skies, especially at a local star party or a big astronomical convention. Once you look through both eyepieces of a big binoscope, you may be hooked for life!

Now that we have reached the end of the book, I hope that you have developed a further interest in refractor binoscopes and binocular telescopes. Whether you end up buying or building a binocular telescope or refractor binoscope is really only the beginning of your binoscope adventure. If you do end up building one, when you’ve finished it and you’re ready to try it out, you’re going to want to start looking at some really neat deep sky objects with it. I’ve listed the complete Messier list along with some interesting details about each object that Charles Messier recorded in his famous observational record. You can track them down and observe the sky’s wonders with your own binoscope! Once you have observed a few of the Messier objects, you’ll soon want to observe them all. Enjoy!

The Constellations

• Andromeda	• Circinus	• Lacerta	• Piscis Austrinus
• Antlia	• Columba	• Leo	• Puppis
• Apus	• Coma Berenices	• Leo Minor	• Pyxis
• Aquarius	• Corona Australis	• Lepus	• Reticulum
• Aquila	• Corona Borealis	• Libra	• Sagitta
• Ara	• Corvus	• Lupus	• Sagittarius
• Aries	• Crater	• Lynx	• Scorpius
• Auriga	• Crux	• Lyra	• Sculptor
• Bootes	• Cygnus	• Mensa	• Scutum
• Caelum	• Delphinus	• Microscopium	• Serpens
• Camelopardalis	• Dorado	• Monoceros	• Sextans
• Cancer	• Draco	• Musca	• Taurus
• Canes Venatici	• Equuleus	• Norma	• Telescopium
• Canis Major	• Eridanus	• Octans	• Triangulum
• Canis Minor	• Fornax	• Ophiuchus	• Triangulum Australe
• Capricornus	• Gemini	• Orion	• Tucana
• Carina	• Grus	• Pavo	• Ursa Major
• Cassiopeia	• Hercules	• Pegasus	• Ursa Minor
• Centaurus	• Horologium	• Perseus	• Vela
• Cepheus	• Hydra	• Phoenix	• Virgo
• Cetus	• Hydrus	• Pictor	• Volans
• Chamaeleon	• Indus	• Pisces	• Vulpecula

Messier List

(M1)—is known as the famous “Crab Nebula” is a supernova remnant in the constellation Taurus. It has an apparent magnitude **(v)** of about 8.4 and is approximately 6300 light years from our solar system.

(M2)—is a globular cluster in the constellation Aquarius. It has a apparent magnitude (v) of about 6.3 and is 36,000 light years in distance from planet Earth.

(M3)—is a globular cluster located in the constellation Canes Venatici. It has an apparent magnitude (v) of about 6.2 and is approximately 31,000 light years from the planet Earth.

(M4)—is a globular cluster in the constellation Scorpius. It has an apparent magnitude (v) of about 5.9 and is approximately 7000 light years in distance from our solar system.

(M5)—is a globular cluster in the constellation Serpens. It has a apparent magnitude (v) of about 6.65 and is about 23,000 light years in distance from planet Earth.

(M6)—is known as the “Butterfly Cluster” is an open cluster in the constellation Scorpius. It has an apparent magnitude (v) of about 4.2 and is approximately 2000 light years in distance from planet Earth.

(M7)—is known as the "Ptolemy Cluster" and is an open cluster in the constellation Scorpius. It has an apparent magnitude (v) of about 3.3 and is about 1000 light years from planet Earth.

(M8)—is known as the famous "Lagoon Nebula" and is a nebula associated with a cluster located in the constellation Sagittarius. It has an apparent magnitude (v) of about 6.0 and is approximately 6500 light years in distance from planet Earth.

(M9)—is a globular cluster in the constellation Ophiuchus. It has an apparent magnitude of (v) about 7.9 and is approximately 26,000 light years in distance from planet Earth.

(M10)—is a globular cluster in the constellation Ophiuchus. It has an apparent magnitude (v) of about 6.4 and is approximately 13,000 light years in distance from our solar system.

(M11)—is known as the "Wild Duck Cluster" and is an open star cluster located in the constellation of Scutum. It has an apparent magnitude (v) of about 6.3 and is approximately 6000 light years in distance from planet Earth.

(M12)—is a globular cluster in the constellation of Ophiuchus. It has an apparent magnitude (v) of about 7. and is about 18,000 light years away from our solar system.

(M13)—is known as the Great Globular Cluster in the constellation of Hercules. It has an apparent magnitude (v) of about 5.8 and is approximately 22,000 light years in distance from planet Earth.

(M14)—is a globular cluster in the constellation of Ophiuchus. It has a apparent (v) magnitude of about 8.3 and is approximately 27,000 light years from planet Earth.

(M15)—is a globular cluster in the constellation of Pegasus. It has an apparent magnitude (v) of about 6.2 and is approximately 33,000 light years in distance from our solar system.

(M16)—is the well-known "Eagle Nebula" and is a nebula with a cluster located in the constellation Serpens. It has an apparent magnitude (v) of about 6.0 and is approximately 7000 light years away from planet Earth.

(M17)—is known as the "Omega Nebula" (or sometimes called "Swan", "Horseshoe" Nebula or even "Lobster Nebula" and is a nebula with a cluster in the constellation of Sagittarius. It has an apparent magnitude (v) of about 6.0 and is approximately 5000 light years in distance from planet Earth.

(M18)—is an open cluster in the constellation of Sagittarius. It has a apparent magnitude (v) of about 7.5 and is approximately 6000 light years from our solar system.

(M19)—is a globular cluster in Ophiuchus. It has an apparent magnitude (v) of about 7.5 and is about 27,000 light years from planet Earth.

(M20)—is known as the popular "Trifid Nebula" and is a nebula with a cluster located in the constellation of Sagittarius. It has an apparent magnitude (v) of about 6.3 and is approximately 5200 light years in distance from planet Earth.

(M21)—is an open cluster in the constellation of Sagittarius. It has a apparent magnitude (v) of about 6.5 and is approximately 3000 light years in distance from planet Earth.

(M22)—is known as the “Sagittarius Cluster” which is a globular cluster in the constellation of Sagittarius. It has an apparent magnitude (v) of about 5.1 and is approximately 10,000 light years in distance from our solar system.

(M23)—is known as an open cluster in the constellation of Sagittarius. It has an apparent magnitude (v) of about 6.9 and is approximately 4500 light years in distance from our solar system.

(M24)—is known as the “Sagittarius Star Cloud” and is a Milky Way star cloud with an apparent magnitude (v) of about 4.6 and is located approximately 10,000 light years in distance from planet Earth.

(M25)—is an open cluster located in the constellation of Sagittarius. It has an apparent magnitude (v) of about 4.6 and is about 2000 light years from our solar system.

(M26)—is an open cluster in the constellation Scutum. It has a apparent magnitude (v) of about 8.0 and is about 5000 light years in distance from our solar system.

(M27)—is the famous “Dumbbell Nebula” and is a planetary nebula in the constellation of Vulpecula. It has an apparent magnitude (v) of about 7.5 and is 1250 light years away from our solar system.

(M28)—is a globular cluster in the constellation of Sagittarius. It has an apparent magnitude (v) of about 7.7 and is approximately 18,000 light years in distance from planet Earth.

(M29)—is an open cluster located in the constellation of Cygnus, otherwise noted as the “Swan”. It has a apparent magnitude (v) of about 7.1 and is about 7200 light years in distance from our solar system.

(M30)—is a globular cluster in constellation of Capricornus. It has an apparent magnitude (v) of about 7.7 and is about 25,000 light years from planet Earth.

(M31)—is known as the famous “Andromeda Galaxy” is a spiral galaxy in the constellation of Andromeda. It has an apparent magnitude (v) of about 3.44 and is approximately 2.5 million light years in distance from planet Earth.

(M32)—is a dwarf elliptical galaxy that is located in the constellation of Andromeda. It has an apparent magnitude (v) of about 8.1 and is approximately 2.9 million light years in distance from our solar system.

(M33)—is known as the “Triangulum Galaxy” and is a spiral galaxy located in the constellation of Triangulum. It has an apparent magnitude (v) of 5.7 and is approximately 2.81 million light years in distance from our solar system.

(M34)—is an open cluster located in the constellation of Perseus. It has an apparent magnitude (v) of about 5.5 and is approximately 1400 light years away from planet Earth.

(M35)—is an open cluster in the constellation of Gemini. It has an apparent magnitude (v) of about 5.3 and is approximately 2800 light years in distance from our solar system.

(M36)—is an open cluster in the constellation of Auriga, otherwise known as the “Charioteer”. It has an apparent magnitude (v) of about 6.3 and is approximately 4100 light years in distance from our solar system.

(M37)—is an open cluster in the constellation of Auriga. It has a apparent magnitude (v) of about 6.2 and is approximately 4600 light years from planet Earth.

(M38)—is an open star cluster in the constellation of Auriga. It has an apparent magnitude (v) of about 7.4 and is approximately 4200 light years in distance from planet Earth.

(M39)—is an open cluster in the constellation of Cygnus. It has an apparent magnitude (v) of about 5.5 and is approximately 800 light years from planet Earth.

(M40)—is a double star, located some 500 light years away from planet Earth, and it's pointed in the direction of the constellation of Ursa Major. It has an apparent magnitude (v) of about 9.65 + 10.10.

(M41)—is an open cluster in Canis Major. It has an apparent magnitude (v) of 4.5 and is about 2300 light years in distance from planet Earth.

(M42)—the famous "Orion Nebula" and is a nebula located in the constellation of Orion, otherwise known as the "Hunter". It has an apparent magnitude (v) of about 4.0 and is approximately 1600 light years distance from planet Earth.

(M43)—is known as "De Mairan's Nebula" and is part of the Orion Nebula in the constellation of Orion. It has a apparent magnitude (v) of about 9.0 and is approximately 1600 light years distant from our solar system.

(M44)—is known as "Praesepe" or more commonly called the "Beehive Cluster" and is noted as an open cluster located in the constellation of Cancer. It has a apparent magnitude (v) of about 3.7 and is approximately 600 light years in distance from planet Earth.

(M45)—is known as the "Pleiades" or more commonly called the "Seven Sisters" and is noted as an open star cluster located in the constellation of Taurus constellation. It has an apparent magnitude (v) of about 1.6 and is approximately 400 light years from planet Earth.

(M46)—is an open cluster with an apparent magnitude (v) of about 6.1. It is approximately 5400 light years from planet Earth in the direction of the constellation of Puppis.

(M47)—is an open cluster in the constellation of Puppis. It has an apparent magnitude (v) of about 4.2 and it lies approximately 1600 light years from planet Earth.

(M48)—is an open cluster in the constellation of Hydra, also known as the "Water Snake". It has a apparent magnitude (v) of about 5.5 and is approximately 1500 light years in distance from our solar system.

(M49)—is known as an elliptical galaxy located in the constellation of Virgo. It has an apparent magnitude (v) of about 9.4 and is approximately 60 million light years in distance from the planet Earth.

(M50)—is an open star cluster in the constellation of Monceros, also known as "the Unicorn". It has an apparent magnitude (v) of about 5.9 and is approximately 3000 light years from planet Earth..

(M51)—is known as the famous "Whirlpool Galaxy", and it is a spiral galaxy that lies in the constellation of Canes Venatici, also known as "the Hunting Dogs". It has an apparent magnitude (v) of about 8.4 and is approximately 37 million light years from planet Earth.

(M52)—is an open cluster in the constellation of Cassiopeia. It has an apparent magnitude (v) of about 5.0 and is approximately 7000 light years from planet Earth.

(M53)—is a globular star cluster in the constellation of Coma Berenices, and is also known as “Berenice’s Hair”. The cluster has an apparent magnitude (v) of about 8.3 and is approximately 56,000 light years in distance from our solar system.

(M54)—is a globular cluster with an apparent magnitude (v) of about 8.4. It is located in the constellation of Sagittarius at a distance of about 83,000 light years from planet Earth.

(M55)—is known as a globular star cluster in the constellation of Sagittarius. It has an apparent magnitude (v) of about 7.4 and is approximately 17,000 light years from our solar system.

(M56)—is a globular cluster in the constellation of Lyra. It has an apparent magnitude (v) of about 8.3 and is approximately 32,000 light years in distance from planet Earth.

(M57)—is known as the “Ring Nebula” and is known as a planetary nebula located in the constellation of Lyra. It has an apparent magnitude (v) of about 8.8 and is approximately 2300 light years from the planet Earth.

(M58)—is known as a barred spiral galaxy in the constellation of Virgo. It has an apparent magnitude (v) of about 10.5 and is approximately 60 million light years in distance from our solar system.

(M59)—is known as an elliptical galaxy in the constellation of Virgo. It has an apparent magnitude (v) of about 10.6. It is approximately 60 million light years from planet Earth.

(M60)—is known as an elliptical galaxy in the constellation of Virgo. It has an apparent magnitude (v) of about 9.8 and is approximately 60 million light years from plane Earth.

(M61)—is known as a spiral galaxy in constellation of Virgo. It has an apparent magnitude (v) of about 10.2 and is about 60 million light years from planet Earth.

(M62)—is known as a globular cluster located in the constellation of Ophiuchus, also known as “the Serpent Bearer”. It has an apparent magnitude (v) of about 7.4 and is approximately 22,000 light years from planet Earth.

(M63)—is also known as the “Sunflower Galaxy”. It is noted as a spiral galaxy in the constellation of Canes Venatici. It has an apparent magnitude (v) of about 9.3 and is approximately 37 million light years from planet Earth.

(M64)—is better known as the “Black Eye Galaxy”, and it is a spiral galaxy in the constellation of Coma Berenices. It has n apparent magnitude (v) of about 9.4 and lies approximately 12 million light years from our solar system.

(M65)—is known as a barred spiral galaxy that is a member of the “Leo Triplet” in the constellation of Leo. It has an apparent magnitude (v) of about 10.3 and is approximately 35 million light years in distance from planet Earth.

(M66)—is known to be a barred spiral galaxy that is a member of the “Leo Triplet” of galaxies. It has an apparent magnitude (v) of about 8.9 and is located approximately 35 million light years from planet Earth in the constellation of Leo.

(M67)—is known to be an open cluster in the constellation of Cancer. It has an apparent magnitude (v) of about 6.1 and is approximately 2250 light years in distance from planet Earth.

(M68)—is known to be a globular cluster in the constellation of Hydra. It has an apparent magnitude (v) of about 9.7 and lies approximately 32,000 light years from our solar system.

(M69)—is known to be a globular star cluster in the constellation of Sagittarius. It has an apparent magnitude (v) of about 8.3 and is approximately 25,000 light years from planet Earth.

(M70)—is known to be a globular cluster in the constellation of Sagittarius. It has an apparent magnitude (v) of about 9.0 and is approximately 28,000 light years from planet Earth.

(M71)—is noted to be a globular cluster in the constellation of Sagitta, also known as "the Arrow". It has an apparent magnitude (v) of about 6.1 and is approximately 12,000 light years from planet Earth.

(M72)—is known to be a globular cluster in the constellation of Aquarius. It has an apparent magnitude (v) of about 9.4 and is approximately 53,000 light years from our solar system.

(M73)—is known as an "asterism" in the constellation of Aquarius. It has an apparent magnitude (v) of about 9.0. No distance is given.

(M74)—is known as a spiral galaxy in the constellation of Pisces. It has an apparent magnitude (v) of about 10.0 and is approximately 35 million light years in distance from planet Earth.

(M75)—is known to be a globular cluster located in the constellation of Sagittarius. It has a an apparent magnitude (v) of about 9.2 and is approximately 58,000 light years in distance from planet Earth.

(M76)—is also known as the "Little Dumbbell Nebula". It is located about 3400 light years in distance in the constellation of Perseus. It is classified as a planetary nebula with an apparent magnitude (v) of about 10.1.

(M77)—is also known as "Cetus A". It is known to be a spiral galaxy located in the constellation of Cetus, often called "the Whale". It has an apparent magnitude (v) of about 9.6 and is approximately 60 million light years in distance from planet Earth.

(M78)—is known as a "diffuse nebula" in constellation of Orion. It has an apparent magnitude (v) of about 8.3 and is approximately 1600 light years from our solar system.

(M79)—is known as a globular cluster in the constellation of Lepus, also known as "the Hare". It has an apparent magnitude (v) of about 8.6 and is approximately 40,000 light years in distance from the planet Earth.

(M80)—is known to be a globular cluster in the constellation of Scorpius. It has an apparent magnitude (v) of about 7.9 and is approximately 27,000 light years from planet Earth.

(M81)—is also known as "Bode's Galaxy". It is a spiral galaxy located in the constellation of Ursa Major. It has an apparent magnitude (v) of about 6.9 and lies approximately 12 million light years from our solar system.

(M82)—is known as the famous "Cigar Galaxy" and is classified as a starburst galaxy located in the constellation of Ursa Major. It has a apparent magnitude (v) of about 8.4 and is approximately 11 million light years from the planet Earth.

(M83)—is commonly known as the “Southern Pinwheel Galaxy”. It is a barred spiral galaxy in the constellation of Hydra. It has an apparent magnitude (v) of about 7.5 and is approximately 10 million light years from the planet Earth.

(M84)—is known as a “lenticular galaxy” in the constellation of Virgo. It has an apparent magnitude (v) of about 10.1 and is approximately 60 million light years in distance from our solar system.

(M85)—is known to be a “lenticular galaxy” in the Coma Berenices constellation. It has an apparent magnitude (v) of about 10.0 and is about 60 million light years in distance from the planet Earth.

(M86)—is also known to be a lenticular galaxy located in the constellation of Virgo. It has an apparent magnitude (v) of about 9.0 and is approximately 60 million light years in distance from our solar system..

(M87)—is also known as “Virgo A”, an elliptical galaxy located in the constellation of Virgo. It has an apparent magnitude (v) of about 9.6 and is approximately 60 million light years from planet Earth.

(M88)—is known to be a spiral galaxy in Coma Berenices constellation. It has an apparent magnitude (v) of about 10.4 and is approximately 60 million light years from planet Earth.

(M89)—is known as an elliptical galaxy in the constellation of Virgo. It has an apparent magnitude (v) of about 10.7 and is approximately 60 million light years from planet Earth.

(M90)—is known as a spiral galaxy in the constellation of Virgo. It has a an apparent magnitude (v) of about 10.3 and is approximately 60 million light years from our solar system.

(M91)—is a barred spiral galaxy located in Coma Berenices. It has an apparent magnitude (v) of about 11.0 and is approximately 60 million light years distant.

(M92)—is a globular star cluster in the constellation of Hercules. It has an apparent magnitude (v) of about 6.3 and is about 26,000 light years from planet Earth.

(M93)—is an open cluster in Puppis constellation. It has an apparent magnitude (v) of 6.0 and is approximately 4500 light years from planet Earth.

(M94)—is also known as the “Cat’s Eye Galaxy” or “Croc’s Eye Galaxy”. It is a spiral galaxy in Canes Venatici constellation. It has an apparent magnitude (v) of about 9.0 and is about 14.5 million light years from our solar system.

(M95)—is a barred spiral galaxy in the constellation of Leo. It has an apparent magnitude (v) of about 11.4 and is approximately 38 million light years from planet Earth.

(M96)—is a spiral galaxy in the constellation of Leo. It has an apparent magnitude (v) of about 10.1 and is about 38 million light years distance from planet Earth.

(M97)—is known as the “Owl Nebula”. It is a planetary nebula located in the constellation of Ursa Major. It has an apparent magnitude (v) of about 9.9 and is approximately 2600 light years distant from planet Earth.

(M98)—is a spiral galaxy in Coma Berenices constellation. It has an apparent magnitude (v) of about 11.0 and is about 60 million light years from planet Earth.

(M99)—is a spiral galaxy in Coma Berenices. It has an apparent magnitude (v) of 10.4 and is about 60 million light years distant from Earth.

(M100)—is a spiral galaxy in Coma Berenices constellation. It has an apparent magnitude (v) of about 9.5 and is approximately 60 million light years from our solar system.
(M101)—is the famous "Pinwheel Galaxy", is a spiral galaxy in Ursa Major. It has an apparent magnitude (v) of about 7.9 and is about 27 million light years distance from planet Earth.
(M102)—listed as a galaxy, but the object has yet to be conclusively identified. The most likely candidate is the Spindle Galaxy (NGC 5866) in the constellation Draco. Est. Mag. 9.9
(M103)—is an open cluster in Cassiopeia constellation. It has an apparent magnitude (v) of 7.4 and is approximately 8000 light years distant from Earth.
(M104)—is known as the "Sombrero Galaxy". It is a spiral galaxy located in the constellation of Virgo. It has an apparent magnitude (v) of about 9.0 and is approximately 50 million light years from planet Earth.
(M105)—is an elliptical galaxy in the constellation of Leo. It has an apparent magnitude (v) of about 10.2 and is about 38 million light years from our solar system.
(M106)—is a spiral galaxy in the constellation of Canes Venatici. It has an apparent magnitude (v) of about 9.1 and is about 25 million light years distance from the planet Earth.
(M107)—is a globular cluster in the constellation of Ophiuchus It has an apparent magnitude (v) of about 8.9 and is approximately 20,000 light years from planet Earth.
(M108)—is a barred spiral galaxy in the constellation of Ursa Major. It has an apparent magnitude (v) of about 10.7 and is approximately 45 million light years distance from planet Earth
(M109)—is a barred spiral galaxy located in Ursa Major constellation. It has an apparent magnitude (v) of about 10.6 and is about 55 million light years from our solar system.
(M110)—is a dwarf elliptical galaxy in the constellation of Andromeda. It has an apparent magnitude (v) of about 8.92 and is approximately 2.2 million light years from planet Earth.

Selected NGC Objects

1. **(NGC 105)**—a spiral galaxy galaxy in Pisces Mag. (v) 14.1
2. **(NGC 110)**—an open star cluster in Cassiopeia. Mag. (v) 9.0
3. **(NGC 209)**—a lenticular galaxy in Cetus. Mag. (v) 14.7
4. **(NGC 221)**—a dwarf elliptical galaxy in Andromeda. Ma. (v) 8.08
5. **(NGC 225)**—an open cluster in Cassiopeia. Mag. (v) 7.0
6. **(NGC 253)**—a bright galaxy in the Scupltor. Mag. (v) 8.0
7. **(NGC 297)**—a galaxy in Cetus. Mag. (v) 17.3
8. **(NGC 381)**—an open cluster in Cassiopeia. Mag. (v) 9.3

9. **(NGC 598)**—a spiral galaxy in Triangulum. Mag. (v) 5.7
10. **(NGC 613)**—a barred spiral galaxy in the constellation Sculptor. Mag. (v) 10.0
11. **(NGC 660)**—a peculiar and polar-ring galaxy in Pisces. Mag. (v) 12.0
12. **(NGC 752)**—a bright cluster in Andromeda. Mag. (v) 5.7
13. **(NGC 869)**—h Persei, a double cluster with chi. Mag. (v) 3.7
14. **(NGC 884)**—chi Persei, a double cluster with h. Mag. (v) 3.8
15. **(NGC 891)**—an edge-on spiral galaxy in Andromeda. Mag. (v) 10.8
16. **(NGC 1055)**—an edge-on spiral galaxy in M77 group. Mag. (v) 11.4
17. **(NGC 1432)**—Maia Nebula in the Pleiades (M45). Mag. (v) 13.
18. **(NGC 1435/IC349/Merope)**—Tempel's Merope Nebula in the Pleiades (M45). Mag. (v) 13.0>IC 349/Mag. (v) 8.0>Merope
19. **(NGC 2023)**—is a bright reflection nebula located near the Horsehead Nebula.
20. **(NGC 2070)**—Tarantula Nebula in the Large Magellanic Cloud. Mag. (v) 8.0
21. **(NGC 2169)**—an open cluster in Orion. Mag. (v) 5.9
22. **(NGC 2175)**—an open cluster in Orion. Mag. (v) 6.8
23. **(NGC 2204)**—an open cluster in Canis Major. Mag. (v) 8.6
24. **(NGC 2237)**—is part of the Rosette Nebula. Mag. (v) 9.0
25. **(NGC 2238)**—is part of the Rosette Nebula.
26. **(NGC 2239)**—is part of the Rosette Nebula.
27. **(NGC 2244)**—a cluster in the Rosette Nebula. Mag. (v) 4.8
28. **(NGC 2246)**—is part of the Rosette Nebula.
29. **(NGC 2264)**—the Cone Nebula and associated cluster. Mag. (v) 3.9
30. **(NGC 2349)**—is an open cluster in Monoceros.
31. **(NGC 2360)**—is an open cluster in Canis Major. Mag. (v) 7.2
32. **(NGC 2362)**—is an open cluster in Canis Major. Mag. (v) 4.1
33. **(NGC 2403)**—is a Sc galaxy in the M81 group. Mag. (v) 8.2
34. **(NGC 2419)**—is an outlying globular cluster in Lynx. Mag. (v) 9.06
35. **(NGC 2438)**—is a planetary nebula in front of M46. Mag. (v) 10.8
36. **(NGC 2451)**—a bright cluster in Puppis. Mag. (v) 3.0
37. **(NGC 2477)**—a rich bright cluster in the constellation Puppis. Mag. (v) 5.8
38. **(NGC 2516)**—a bright cluster in Carina. Mag. (v) 3.8
39. **(NGC 2546)**—a considerable cluster in Puppis. Mag. (v) 6.3
40. **(NGC 2547)**—a very populated cluster in Vela. Mag. (v) 4.7
41. **(NGC 2903)**—a very bright spiral galaxy in Leo. Mag. (v) 9.7
42. **(NGC 2976)**—a faint companion of M81 and M82. Mag. (v) 10.8
43. **(NGC 3077)**—a companion of M81 and M82. Mag. (v) 9.6
44. **(NGC 3115)**—known as the Spindle Galaxy (Caldwell 53) in Sextans. Mag. (v) 9.9
45. **(NGC 3228)**—a considerable open cluster in Vela. Mag. (v) 6.0
46. **(NGC 3293)**—a bright open cluster in Carina. Mag. (v) 4.7
47. **(NGC 3372)**—also known as the Eta Carinae nebula. Mag. (v) 1.0
48. **(NGC 3532)**—a bright open cluster in Carina. Mag. (v) 3.0
49. **(NGC 3628)**—is the third of the Leo Triplet (with M65 and M66). Mag. (v) 10.2
50. **(NGC 3766)**—a concentrated cluster in Centaurus. Mag. (v) 5.3

51. **(NGC 3953)**—is a barred spiral galaxy near M109. Mag. (v) 10.8
52. **(NGC 4565)**—is a large bright edge-on spiral in Coma. Mag. (v) 10.4
53. **(NGC 4571)**—is a barred spiral in Virgo cluster. Mag. (v) 11.8
54. **(NGC 4631)**—is known as the Herring or Whale Galaxy. Mag. (v) 9.8
55. **(NGC 4656/57)**—an irregular looking spiral galaxy in Canes Venatici. Mag. 11.0
56. **(NGC 4755)**—is known as Kappa Cruxis, the Jewel Box cluster. Mag. (v) 4.2
57. **(NGC 4833)**—is a southern globular cluster in Musca. Mag. (v) 7.8
58. **(NGC 5128)**—is peculiar and a radio galaxy Centaurus A. Mag. (v) 6.84
59. **(NGC 5139)**—a globular cluster Omega Centauri. Mag. (v) 3.9
60. **(NGC 5195)**—a companion of **M51**. Mag. (v) 10.5
61. **(NGC 5281)**—a small compact open cluster in Centaurus. Mag. (v) 5.9
62. **(NGC 5662)**—a considerable southern cluster in Centaurus. Mag. (v) 5.5
63. **(NGC 5907)**—in the same group with **M102** candidate NGC 5866. Mag. (v) 11.1
64. **(NGC 6025)**—a considerable open cluster in Triangulum Australe. Mag. (v) 5.1
65. **(NGC 6124)**—a considerable open cluster in the constellation Scorpius. Mag. (v) 5.8
66. **(NGC 6231)**—a bright open cluster in the constellation Scorpius. Mag. (v) 2.6
67. **(NGC 6242)**—an open cluster in the constellation Scorpius. Mag. (v) 6.4
68. **(NGC 6397)**—a nearby globular cluster in Ara. Mag. (v) 6.7
69. **(NGC 6530)**—open cluster associated with the Lagoon Nebula **M8**. Mag. 4.6
70. **(NGC 6543)**—known as the Cat Eye nebula, a planetary near the N.E.P. Mag. 8.1
71. **(NGC 6603)**—an open cluster in the star cloud **M24.** Mag. 11.4
72. **(NGC 6633)**—a bright open cluster in the constellation Ophiuchus. Mag. 4.6
73. **(NGC 6712)**—a globular cluster in Scutum. Mag. 8.1
74. **(NGC 6819)**—an open cluster in the constellation Cygnus. Mag. 7.3
75. **(NGC 6822)**—known as Barnard's Galaxy, an irregular Local Group galaxy. Mag. 9.3
76. **(NGC 6866)**—an open cluster in the constellation Cygnus. Mag. 7.6
77. **(NGC 6946)**—a spiral galaxy in the constellation Cepheus. Mag. 8.9
78. **(NGC 7000)**—known as the North America Nebula. Apparent Mag. 4.0
79. **(NGC 7009)**—known as the Saturn Nebula. Mag. 8.0
80. **(NGC 7293)**—also known as the Helix Nebula. Mag. 7.3
81. **(NGC 7331)**—a conspicuous spiral galaxy in the constellation Pegasus. Mag. 9.5
82. **(NGC 7380)**—an open cluster with nebula in the constellation Cepheus. Mag. 7.2
83. **(NGC 7479)**—a barred spiral galaxy in the constellation Pegasus. Mag. 11.0
84. **(NGC 7789)**—a bright open cluster in the constellation Cassiopeia. Mag. 6.7

Selected IC Objects

1. **(IC 10)**—an outlying irregular dwarf member of the Local Group. Mag. (v) 10.4+−.2
2. **(IC 348)**—a star forming region in the constellation Perseus. Mag. (v) 7.3
3. **(IC 349)**—known as Barnard's Merope Nebula in the Pleiades **(M45)**. Mag. (v) 13.0
4. **(IC 434)**—the emission nebula behind the Horsehead Nebula. App. Mag. (v) 7.3
5. **(IC 1434)**—an open cluster in Lacerta. Mag. (v) 9.0
6. **(IC 2391)**—Open cluster known as Omicron Velorum in Vela. Mag. (v) 2.5
7. **(IC 2395)**—vdB-Ha 47, an open scattered cluster in Vela. Mag. (v) 4.6
8. **(IC 2488)**—an inconspicuous cluster in the constellation Vela. Mag. (v) 7.4p
9. **(IC 2602)**—known as the Theta Carinae cluster, (the Southern Pleiades). Mag. (v) 1.9
10. **(IC 5148)**—a planetary nebula located in the constellation Grus. Mag. (v) 16.5
11. **(IC 4665)**—a coarse bright cluster in the constellation Ophiuchus. Mag. (v) 4.2
12. **(IC 5152)**—an irregular dwarf member of the Local Group. Mag. (v) 10.5

Some of the Author's Favorite Intragalactic Objects

1. **(Barnard 33)**—known as the Horsehead Nebula.
2. **(Barnard 92)**—a dark nebula associated with M24.
3. **(Barnard 93)**—a dark nebula associated with M24.
4. **(Barnard's Loop)**—(Sharpless 276, Sh2-276).
5. **(Brocchi's Cluster)**—(Collinder 399, Cr 399).
6. **(Canis Major Dwarf)**—a disputed nearby irregular galaxy in the local group.
7. **(Coalsack Dark Nebula)**—that appears in the southern Milky Way.
8. **(Collinder 140)**—(Cr 140)—an open cluster in southern Canis Major.
9. **(Collinder 228)**—(Cr 228)—an open cluster within the Great Carina Nebula.
10. **(The Hyades)**—(Meylotte 25, Mel 25)—a beautiful open cluster in Taurus.
11. **(Eta Carinae)**—one of the most massive and luminous, and spectacular stars.
12. **(G1 (Mayall II)**—the brightest globular in **M31**.
13. **(Coma Star Cluster)**—(Melotte 111, Mel 111).
14. **(The Large Magellanic Cloud)**—(LMC).
15. **(Leo I—The Regulus Galaxy)**—a Dwarf Elliptical Galaxy in Local Group.
16. **(M-42)**—The Great Nebula in Orion.
17. **(The Maffei 1 Group of galaxies)**—thought to be once part of our Local Group.

Selected Objects in the Milky Way: Our Galaxy

1. **(M8)**—the Lagoon Nebula in Sagittarius.
2. **(SagDEG)**—nearby Sagittarius Dwarf Elliptical Galaxy containing globular **M54**
3. **(Sculptor Group of Galaxies)**—also South Polar Group
4. **(The Small Magellanic Cloud)**—(**SMC**)
5. **(Trumpler 10)**—(Tr 10), open cluster, presumably Lacaille II.6
6. **(The Ursa Major Moving Cluster)**—(Collinder 285, Cr 285)
7. **(Van den Bergh-Hagen 47)**—(vdB-Ha 47, BH 47)—an open cluster, presumably **IC I IC IC2395**
8. **(Wolf-Lundmark-Melotte)**—(**WLM**)—a remote Local Group galaxy

Note: NGC, IC objects…etc. listed above are just some of the author's favorite celestial objects…and all of them are easily found on most sky atlases and star maps. Some of them can present a challenge for any keen observer even with a large binoscope. *Lists above are adapted from : en.wikipedia.org.

Astronomical Societies

1. Amateur Astronomers Association of Pittsburgh
2. American Association of Variable Star Observers
3. American Astronomical Society
4. American Meteor Society, an amateur organization specializing in meteor observations.
5. Association of Lunar and Planetary Observers, an amateur organization
6. Astronomical League, an umbrella organization of U.S. amateur astronomy societies.
7. Astronomical Society of Australia (ASA)
8. Astronomical Society of Glasgow
9. Astronomical Society of New South Wales, based in Sydney, Australia.
10. Astronomical Society of South Australia
11. Astronomical Society of Southern Africa
12. Astronomical Society of the Pacific
13. Astronomical Society of Victoria, based in Melbourne, Australia.
14. Astronomical Society Ruder Boskovic, from Belgrade Serbia
15. Astronomische Gesellschaft (German Astronomical Society)
16. Birmingham Astronomical Society, in Birmingham, Alabama
17. British Astronomical Association (BAA)
18. Confederation of Indian Amateur Astronomer Association (India)
19. Cornell Astronomical Society.
20. Crayford Manor House Astronomical Society
21. Escambia Amateur Astronomers Association, Northwest Florida.

22. EAAE—European Association for Astronomy Education, a European Association that promotes activities for schools, teachers and students.
23. Federation of Astronomical Societies (UK)
24. International Meteor Organization, an international organization dealing in meteor observations.
25. Jyotirvidya Parisanstha (Pune, India)
26. Kauai Educational Association for Science and Astronomy (Kauai, Hawaii)
27. Khagol vishwa (India)
28. Khagol Mandal (Mumbai, India)
29. Kopernik Astronomical Society (Vestal, New York)
30. Louisville Astronomical Society
31. Macarthur Astronomical Society, based in south-western Sydney, Australia
32. Mohawk Valley Astronomical Society, Central New York, USA
33. Mornington Peninsula Astronomical Society, based in Victoria, Australia.
34. Network for Astronomy School Education (NASE)
35. Northern Virginia Astronomy Club
36. Northumberland Astronomical Society
37. Nottingham Astronomical Society, Nottingham, England, UK
38. Pakistan Amateur Astronomers Society
39. The Planetary Society
40. Polish Astronomical Society
41. Royal Astronomical Society in London
42. Royal Astronomical Society of Canada
43. Royal Astronomical Society of New Zealand
44. SETI Institute
45. Shreveport-Bossier Astronomical Society
46. Society astronomique de France, the French astronomical society
47. Society for the History of Astronomy
48. Society for Popular Astronomy based in the United Kingdom for beginners to amateur astronomy
49. Southern Cross Astronomical Society, based in Miami, Florida, US.
50. Sutherland Astronomical Society based in the southern suburbs of Sydney, Australia.
51. Spaceturk, an amateur organization specializing in planetary, lunar, and other solar system observations in Turkey
52. Whakatane Astronomical Society

Note: For those who are looking for an astronomy club or astronomical society to join, the list above will help you locate a club or society near you. Their websites are easily found on the internet along with their contact information. (Adapted from en.wikipedia.org) (Figs. 10.42, 10.43, 10.44, 10.45, and 10.46).

Fig. 10.42 Jan Pavlacka a Virginia amateur astronomer is putting his 70's Jason 7×50 binoc's to good use scanning the sky just before sunset for any mysterious cosmic interlopers. Lucky for Jan on this particular fine evening that a Venus/Jupiter conjunction has caught his observing attention. (Image credit: Jan and Carolyn Pavlacka)

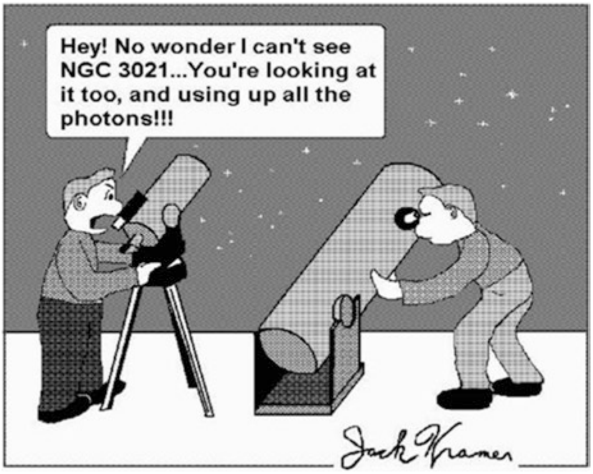

Fig. 10.43 (Cartoon credit: Jack Kramer)

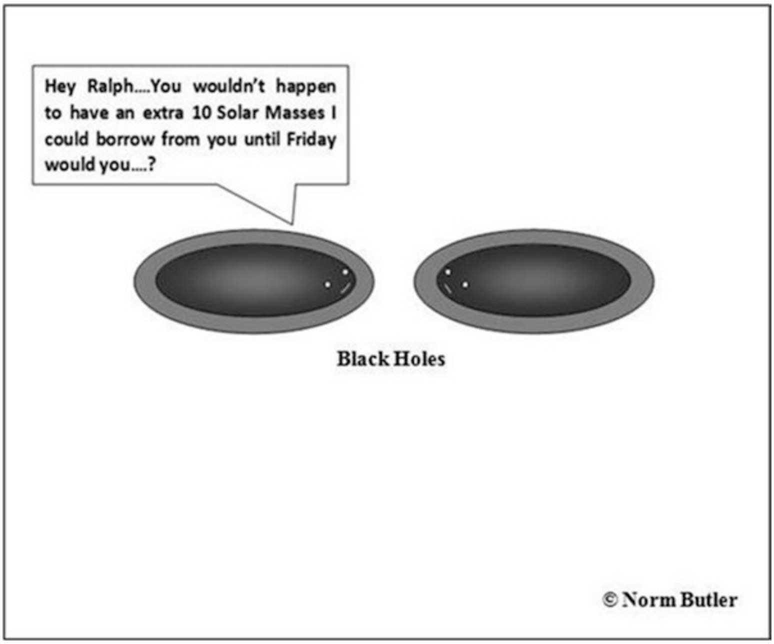

Fig. 10.44 (Cartoon credit: the Author)

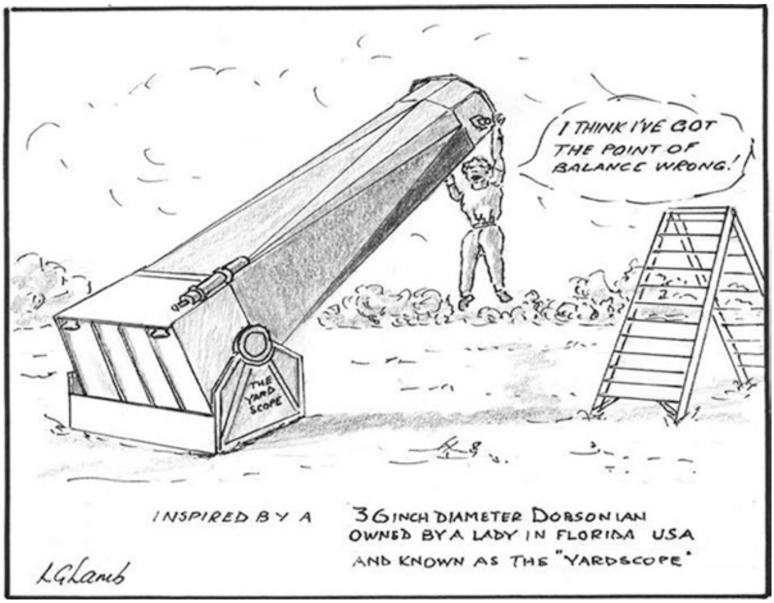

Fig. 10.45 (Cartoon credit: Les Lamb)

Fig. 10.46 IC434 More commonly known as the "Horse Head Nebula" in the constellation Orion (Image credit: Sara Wager - www.swagastro.com)

Further Reading

Alex Tat-Sang Choy. A asymmetric binocular telescopes. http://www.telescopereviews.com, www.astronomics.com
Astrogizmos. E Z Gazer. http://www.astrogizmos.com
Liming, G. The Bino Chair. http://www.liming.org
Schell, Jochen. http://www.binoscopes.de
The Bolton Group. http://www.deep-sky.co.uk
Wabash Valley Astronomical Society. Eight inch binocular telescope. http://www.stargazing.net
Walton, G. Easy To build binocular chair. http://www.mpas.asn.au