The Binocular Photon Machine

Military High Tech for Astronomy

By Mark Vanderaar

Dark skies, telescope aperture, and careful selection of filters and eyepieces are our best friends when observing deep-sky objects (DSOs). Not much else is available. So when a product comes along that offers another way to easily enhance the DSO viewing experience, it is definitely worth a look.

In this case, the product is called The Binocular Photon Machine (BIPH), and is offered by Night Vision Astronomy (www.nightvisionastronomy.com). The BIPH has generated a buzz across the amateur astronomy community with the opportunity of being able to see detail in objects that were previously only visible photographically.

How is this possible? At the heart of the BIPH is an image intensifier vacuum tube that roughly speaking, "amplifies" the incoming light many thousands of times over. More precisely, an image intensifier first converts the meager number of ancient, well-traveled photons from the object to electrons through the use of a device called a photocathode. This is much like night vision goggles or camcorders with night vision enhanced viewfinders. The ones used in the BIPH are military grade that are provided by the military and are a generation 3 quality which produce a much cleaner image.

These electrons enter a Micro-Channel Plate (MCP). The MCP resembles a bunch of tiny, short soda straws. Each straw represents a tiny part of the image, similar to a pixel. More "straws" means higher sharpness in the resulting image. As each electron hits the side wall of an MCP "straw" multiple secondary electrons are released. In turn these electrons hit the side again creating even more electrons and so on. This process greatly amplifies the signal

Finally, the relatively massive number of electrons is slammed into a phosphor monochrome (green in this case) screen creating photons that are visible to the observer. So, basically what you have is a small number of photons (at various wavelengths) coming in to the BIPH and a much larger number (at a single wavelength) coming out, resulting in a brighter, more detailed image. This is all done in real-time! The BIPH uses what is called generation 3 image intensifier tubes. These are really the first tubes suitable for visual astronomy applications.

Night vision devices gather existing ambient light (starlight, moonlight or infra-red light) through the front lens. This light, which is made up of photons goes into a photocathode tube that changes the photons to electrons. The electrons are then amplified to a much greater number through an electrical and chemical process. The electrons are then hurled against a phosphorus screen that changes the amplified electrons back into visible light that you see through the eyepiece. The image will now be a clear green-hued amplified re-creation of the scene you were observing.

The BIPH embeds the intensifier tube between a front lens and a panoramic eyepiece system. The panoramic eyepiece allows both eyes to be used. The BIPH is extremely simple to use. It has just one power switch, no complicated settings, no wires, and no tracking needed. It is intended to be used just like a regular 2-inch eyepiece, just plug it into your focuser and turn the power switch. No additional eyepiece is needed, all requisite optics are part of the package.

The panoramic eyepiece is probably even simpler to use than a binoviewer in that no interpupillary distance or dual focus adjustment is needed.

Available accessories include an H-alpha filter (pretty much a necessity for observing nebula), a focal reducer, and a barlow. Various star diagonals and power/filter slides from Denkmeier Optical are also sold as accessories. Also available are SLR camera lens attachment kits. These allow the BIPH to be

Image 1 - The BIPH ready for observing in the Richland Astronomical Society's 31-inch f/7 Newtonian.

connected to a camera lens. The result is a binocular-like handheld system that can be used for wide-field views of the night sky.

The BIPH is powered by two AA batteries mounted on the top of the unit. It sips only a little power with a claimed battery life of about 40 hours. It weighs (with batteries installed) in at about 38.4 ounces, which puts it in the same ballpark as a binoviewer with “light” eyepieces. Some telescopes may need additional counterweights. Workmanship of the unit is professional looking and top notch. One area that could be improved is the battery pack that is held in place with a bracket that is in turn held in place with a Velcro strip. This arrangement can loosen, and if you aren’t careful, can leave the battery pack dangling by its wires.

So how well does this gizmo work? What can you see that you couldn’t before? First off, in some ways, the BIPH can be thought of as a substitute for a larger aperture telescope. Night Vision Astronomy says it provides the equivalent of a tripling in aperture. For example, a 6-inch aperture telescope would perform like an 18-inch and an 18-inch like a 54-inch! In practice, this type of gain is only a rough guide. It really ends up being dependent on the type of object, the scope, and the observing conditions.

Since receiving my BIPH in March of 2009, I have used it primarily in three telescopes, all Newtonian reflectors. This includes my personal 6-inch f/4.5 and 18-inch f/4.5, as well as the Richland Astronomical Society’s (www.wro.org) 31-inch f/7 telescope. I have not used the BIPH in a refractor or catadioptric optical systems. The main proprietor of Night Vision Astronomy, Doug Baum, recommends using fast scopes to get the best performance from the BIPH. In slower scopes, a focal reducer can be used increase the effective speed. Those interested in using a BIPH on refractors or cats should contact Doug to discuss the possibilities.

First off, the BIPH provides a very colorful image, unfortunately the color is limited to just one…green. Since the human eye has the most sensitivity near wavelengths that we perceive as green, it was chosen by the designers as the color for the phosphor screen. This is a bit artificial looking at first, but after a while I tend to forget about the green and sometimes (especially when using the H-alpha filter), I could swear the image starts to look white.

The sharpness of objects looks just about as good as with eyepieces. Stars are pretty close to pinpoints. The exception is that really bright stars tend to have what looks like a halo surrounding them. There is also a scintillation effect that is barely noticeable without a filter, but more noticeable when the H-alpha filter is used. The scintillation looks like tiny starburst going off in the amount of a couple per second. After looking for a bit, my mind tends to tune the scintillation completely out. It has been said that the BIPH provides a magnification close to that of a 40-mm eyepiece, though I have not tried to measure it. It doesn't have a particularly wide field of view, but it doesn't really "look" narrow, maybe due to the fact that the one is looking at a phosphor screen and not really through an eyepiece. Also due to the phosphor screen, eye relief is not an issue. You can put your face right up to the eye guard or even stand a couple feet back!

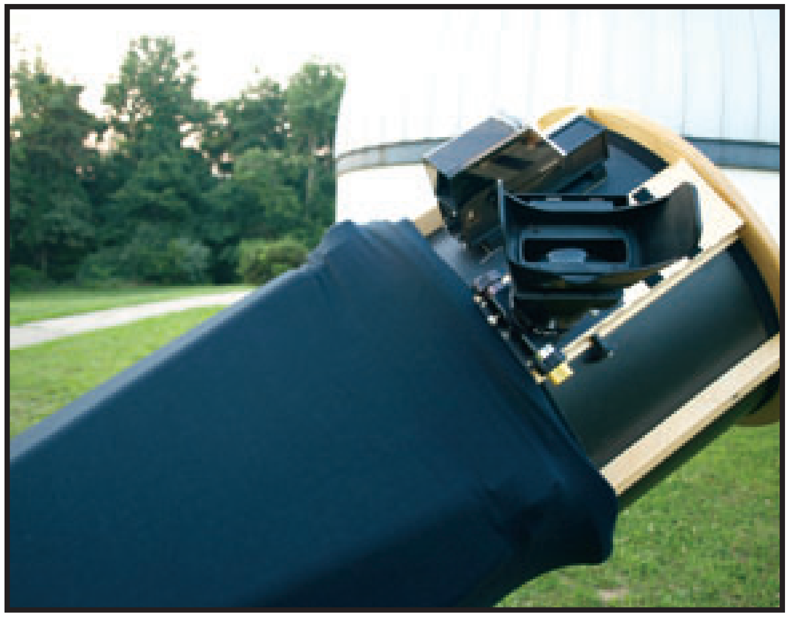


Image 2 - The BIPH in a 18-inch AstroSystem's Telekit

Overall, my experience has been that the BIPH performs best on emission nebula (using the H-alpha filter), globular clusters, edge-on galaxies, dim galaxies, and galaxy clusters. It performs less well on face-on galaxies. Planetary Nebula are a mixed bag and some experimenting is needed as to whether to use a H-alpha filter or not. The performance is also sensitive to transparency

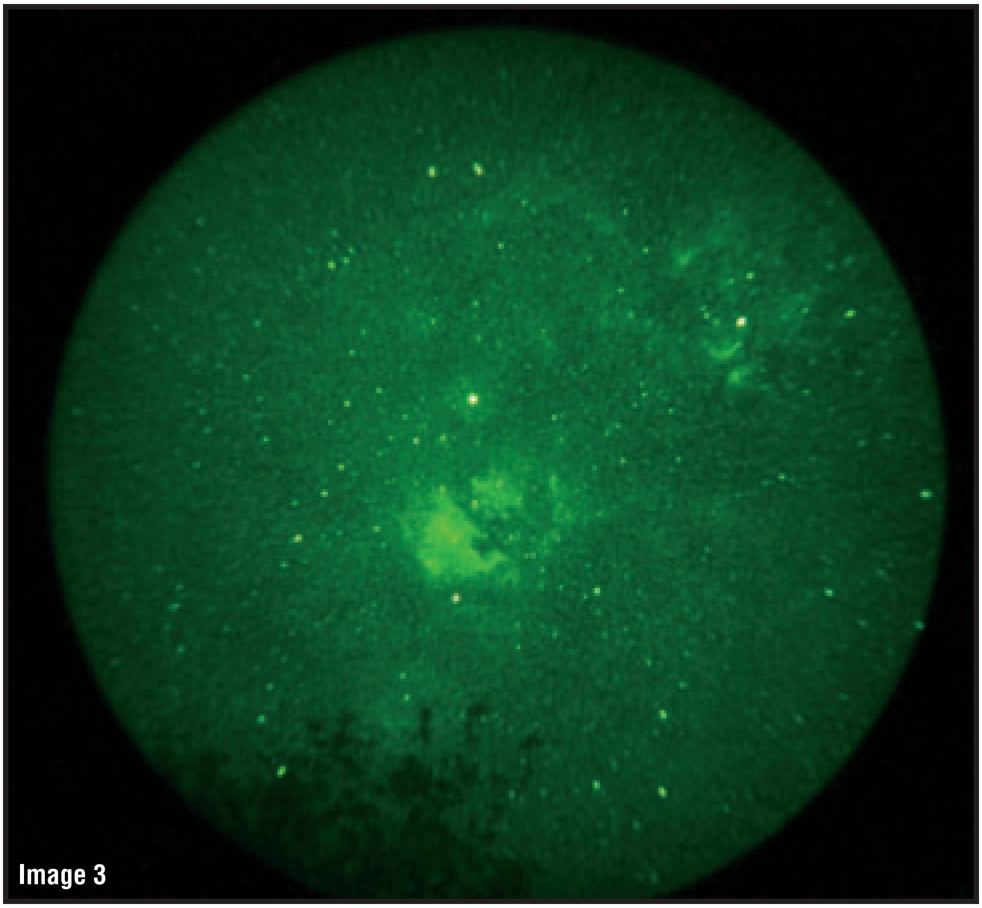


Image 3

conditions. The less transparent the sky is, the brighter the background appears. The exception to this is when using an H-alpha filter. In this case, details in nebula are visible even when some cloud cover or haze is present. For example, I have been able to see significant detail in M17 (the Swan Nebula) even with the naked eye I couldn't see the stars that make up the teapot in Sagittarius.

Also, the BIPH is very sensitive to ambient light, including red lights. If you don't have real good (and opaque) light shrouds and light shields this can be a real problem. The first time we tried the BIPH on the 31-inch all we saw was a bright green background with very few stars. I thought the BIPH was malfunctioning or the f/7 focal length of the 31-inch was too long to use effectively. However, it turned out that a couple of pretty dim red lights in the observatory were the culprit. We turned these off and boom, the fun began.

One of the first objects we looked at in the 31-inch f/7 scope was M82, the Cigar Galaxy. It is an impressive object in most scopes, but the combination of 31-inch of aperture and the BIPH make it truly stunning. Slewing the galaxy into view of the BIPH reminded me of finding a huge battleship in a periscope. The monster of a galaxy just floated into the field of view complete with tons of detail in both the dark lanes and puffy bright areas. I guess the star-forming areas and dark clouds radiate a lot of red/infrared energy. Truly a breathtaking view!

Recently at the 2009 Hidden Hollow Star Party a number of experienced observers got a chance to look at NGC891, a relatively large and dim edge on galaxy with a dark lane through the middle. Almost to a person, most folks said it was the best view of that galaxy they ever had. Interestingly though, a minority of people just didn't really like the view. Though they admitted they could see more detail, they felt the green color and scintillation just made it appear too artificial.

Other memorable views so far in the 31-inch have been the experience of losing count of globular clusters in the Andromeda Galaxy, seeing two stars within the Ring Nebula, observing wispy detail in the extra-galactic nebula NGC 604 (part of the Triangulum Galaxy), and seeing detail in the two closely interacting galaxies in Stephen's Quintet.

With my 18-inch scope, a couple of cool observations stand out. The Great Orion Nebula is simply stunning. First off, the nebula appears so bright and detailed that the trapezium stars start to fade into the nebulosity. In the rest of the nebula, the amount of detail and contrast was indescribable. M42 is pretty incredible in a normal eyepiece, but the BIPH takes it to a whole new level. The Virgo and Perseus Galaxy Clusters also respond well to the BIPH. Globular clusters are significantly brightened by the BIPH. For example, in one evening, I was able to view 9 of the 11 Terzan Globular Clusters.

With my 6-inch travel Dobsonian, the BIPH, and an H-alpha filter I have been able to view the Horsehead Nebula, no averted vision needed.

As mentioned earlier, the BIPH can also be used with an SLR camera lens, making for a night vision enhanced binocular. Besides watching nocturnal animals and pretending to be a special ops soldier, it's great to point this thing skyward. It's really neat to have a scale perspective for the bright nebula. Seeing treetops, the Lagoon Nebula, and the Trifid Nebula, globular clusters, fainter nebula, and countless stars all in one field of view is pretty neat. **Image 3** is a picture (courtesy John Paladini) taken through the BIPH eyepiece using a DSLR. It is a photo of the North American Nebula, Pelican Nebula and Butterfly Nebula all in the same FOV. A 50-mm SLR lens attached to the BIPH was used. For a range of other customer experiences, check out Night Vision Astronomy's web site quotes tab. There is also a yahoo group that can be accessed via the web site.

Since BIPH is easy to use and the images suitably bright, it is a great tool for public outreach. Often, first time observers at these events can sometimes struggle with looking through an eyepiece, especially at deep-sky objects. This is not the case with the BIPH.

Almost always, I know by the reaction of the individual whether the object has drifted out of view. I hear the nearly universal "Wow!!" if the object is visible, if not…it's time for re-pointing! With the H-alpha filter, the BIPH can also be used with nebula even on moonlit nights. So if the public event happens to fall on a moonlit night, the BIPH allows additional objects for people to see that would have been difficult otherwise.

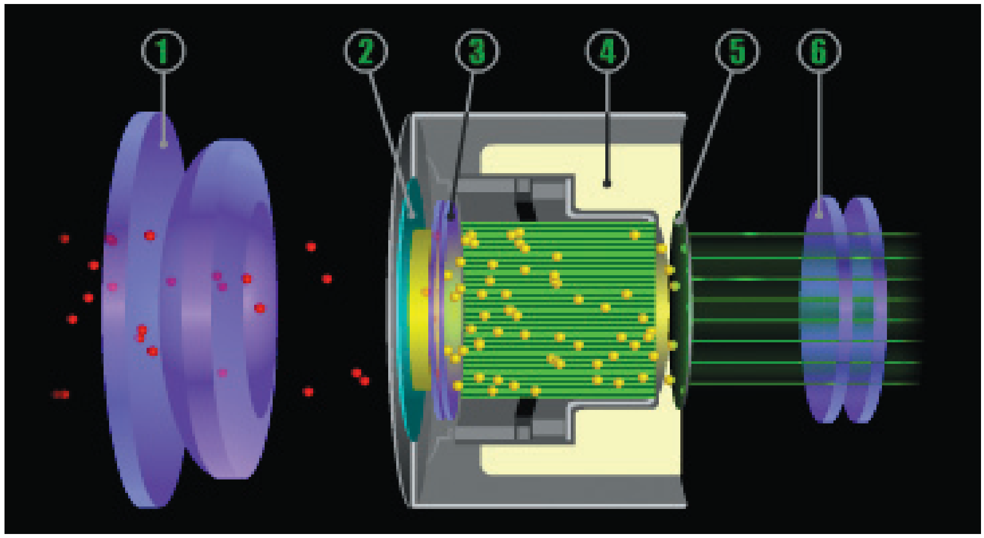
Largely as a result of using some of the latest military technology, the BIPH is by no measure inexpensive. Specifically, the price is driven by the cost of the generation 3 image intensifying tubes. Currently, the BIPH is priced at $3,299 (100% clean used Military Spec tube) or $3,995 (New tube system). This price includes the BIPH, a nice Pelican case, and a personalized laser-cut case badge. More information about which version (used or new tube) to get is provided on the web site. I opted for the used tube for both price and performance reasons. To date, Night Vision Astronomy manufactures the BIPH in batches that they call production runs. They wait until they have enough individual orders to justify a manufacturing turn. This can result in a multi-month lead time on the product. In the future, if there turns out to be sufficient demand for the system, they will likely start to carry them in stock.

In summary, the enhanced and deeper view that the BIPH provides has strongly influenced my observing habits. My guess is that I use it a bit over half my observing time. However, I will always appreciate the direct view of real photons through the eyepiece, something the BIPH can't replace. To me, visual observing can compared to a quiet and intricate classical music composition. The more you listen, the more you appreciate subtle details. After a looking at an object using the BIPH, I feel more like the universe is a big, bright, in-your-face place!

All in all, my purchase of the BIPH was money well spent. It has given me and others views we would never have hope to see. It'll be a great tool for years to come. ATT

How Night Vision Works

As previously described in Mark's article, night vision devices gather existing ambient light (starlight, moonlight or infra-red light) through the front lens. This light, which is made up of photons goes into a photocathode tube that changes the photons to electrons. The electrons are then amplified to a much greater number through an electrical and chemical process. The electrons are then hurled against a phosphorus screen that changes the amplified electrons back into visible light that you see through the eyepiece. The image will now be a clear green-hued amplified re-creation of the scene you were observing. A night vision phosphor screen is purposefully colored green because the human eye can differentiate more shades of green than other phosphor colors.



How Night Vision Works - 1 - Front Lens, 2 – Photocathode, 3 – Micro-channel Plate, 4 - High Voltage Power Supply, 5 - Phosphorus Screen 6 - Eyepiece

A Night Vision Device (NVD) can be a 1st, 2nd, or 3rd generation unit. What this stands for is what type of light intensifier tube is used for that particular device. The light intensifier tube is the heart and soul of an NVD. BIPH utilize the 3rd generation tubes.

1st generation is currently the most popular type of night vision in the world. Utilizing the basic principles described earlier, a 1st generation will amplify the existing light several thousand times letting you clearly see in the dark. These units provide a bright and sharp image at a low cost, which is perfect, whether you are boating, observing wildlife, or providing security for home. The following may be noticed when looking through a 1st generation unit: A slight high-pitched whine when the unit is on; the image seen may be slightly blurry around the edges which is known as geometric distortion; and when you turn a 1st generation off it may glow green for some time.

2nd generation is primarily used by law enforcement or for professional applications. This is because the cost of a 2nd generation unit is approximately $500 to $1000 more then a 1st generation. The main difference between a 1st and a 2nd generation unit is the addition of a micro-channel plate, commonly referred to as a MCP. The MCP works as an electron amplifier and is placed directly behind the photocathode. The MCP consists of millions of short parallel glass tubes. When the electrons pass through these short tubes, thousands more electrons are released. This extra process allows 2nd gen-

eration units to amplify the light many more times than 1st generation giving a brighter and sharper image.

The primary difference between 2nd and 3rd generation is the photocathode. 2nd generation uses a multi alkali photocathode while 3rd generation uses gallium arsenide providing a significant increase in photoresponse and tube life. Other differences in performance are image tube resolution, tube gain and signal to noise ratio. By adding gallium arsenide to the photocathode, a brighter and sharper image was achieved over the 2nd generation. Additionally, the Micro Channel Plate in the generation 3 is coated with an ion barrier film for increased tube life.

The image intensifier (light intensifier tube) is completely self-contained with an integral high-voltage power supply. Equipped with automatic brightness control, this power supply provides constant output image brightness as light levels increase. It also provides bright-source protection to guard the tube against exposure to high levels of light.

The 3rd generation photocathode is very sensitive to low radiation levels of visible and, especially, near infrared light. It also provides very high signal-to-noise ratio for extended detection ranges at very low light levels. The 6-micron channel spacing in the Micro Channel Plate provides exceptional resolution. The MCP has a thin ion-barrier film that preserves photocathode sensitivity during operation, thereby greatly extending the life of generation 3 tubes.

Looking through a night vision device, a user may notice black spots on the screen. A night vision device is similar to a television screen and attracts dust and dirt. Typically these spots can be cleaned. However, this may also be a spot in the tube itself. This is normal. Most tubes will have some spots in them. These black spots will not affect the performance or reliability of the night vision device, however, dark spots will be a distraction if they are large enough or located close to the center of the field of view.

Night Vision Astronomy hand selects 100% clean used tubes for the BIPH and also offers new tubes. While the new tubes are not guaranteed to be clear of dark spots, Night Vision Astronomy uses New Tube Military Specifications for selecting tubes. Dark spot locations are marked in zone 1 (center of field of view), zone 2 or zone 3 which is the outer edge of the field. New Tube Military Specifications allow for 1 spot in zone 2 and another spot in zone 3 that is between 0.006" - .009" and they also allow for 2 spots in zone 2 and 2 spots in zone 3 that are between 0.003" - 0.006". While new tubes are allowed to contain dark spots within military specifications, it does not mean that every new tube Night Vision Astronomy uses has those dark spots. Every tube is different. If the new tube has dark spots, they are within military specifications. ATT