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UNISTELLAR EQUINOX 2 TELESCOPE

Shown is the Lagoon Nebula (M8) captured with the eQuinox 2 in suburban skies with a 10-minute exposure. Note the red colors from the nebula. This amount of nebula detail and no color could never be seen in an eyepiece from the same suburban skies.

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Dr. James Dire follows up his review of the Unistellar eVscope 2 in ATT Volume 17 Issue 3 with his review in this issue of Unistellar's newest scope, the eQuinox 2. As he demonstrates, the eVscope 2 is a solid performer in light polluted suburban skies.

Industry News/New Products

In This Issue

ATT Contributing Writers

Dr. James Dire has a M.S. degree in physics from the University of Central Florida and M.A. and Ph.D. degrees from The Johns Hopkins University, both in planetary science. He has been a professor of chemistry, physics and astronomy and an administrator at several colleges and universities. He has played a key role in several observatory projects including the Powell Observatory in Louisburg, KS, which houses a 30-inch (0.75-m) Newtonian; the Naval Academy observatory with an 8-inch (0.20-m) Alvin Clark refractor; and he built the Coast Guard Academy Astronomical Observatory in Stonington, CT, which houses a 20-inch (0.51-m) Ritchey Chrétien Cassegrain. Dire is a seasoned visual observer and veteran astro-imager.

Matt Harmston is an educational researcher whose appetite for the heavens has been whetted by increasing aperture over the years. More recently, Matt has immersed himself in video astronomy - a means of probing deeper into the night sky while making astronomy accessible to all ages and abilities. With this technology readily available, Matt is considering a career as a sleep-deprivation research subject.

Curtis Macchioni is a physicist who spent most of his career in Silicon Valley working on magnetic data storage technology. Now retired he enjoys the extra time under the night sky and writing about astronomy equipment and methods on his web site www.californiaskys.com and producing astronomy helpful videos on his YouTube channel "Astronomy Tips and Reviews with Curtis." He hopes to attend many of the major star parties across the country over the com

Stuart Parkerson has been the publisher of Astronomy Technology Today since its inception in 2006. While working primarily in the background of the company's magazine and website business operations, he has recently taken a more active role in contributing content covering industry news and other company centric topics.

Mark Zaslove is a two-time Emmy Award winner and recipient of the coveted Humanitas Prize. Mark is a born-again astro noobie, who once had an Optical Craftsman scope as a kid and is now recapturing his youthful enthusiasm (with a digital twist) and having a lovely time doing it.

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Industry News/New Products

THE UNISTELLAR EQUINOX 2 TELESCOPE

By Dr. James R. Dire

I recently reviewed the Unistellar eVscope 2 in this magazine (ATT Volume 17, Issue 3). In this issue I will review their newest scope, the eQuinox 2. The original Unistellar models were the eVscope and the eVscope 2. Both were essentially identical, except the eVscope 2 came with a Nikon "eyepiece", which was really a viewing port on the side of the optical tube assembly that contains a miniature screen displaying the view from the built in camera.

The eVscope 2 telescope comes with a Sony IMX347 camera built into the secondary assembly. This camera has 4.09 megapixels. The eVscope has been rebranded as the eQuinox with is essentially an identical system with a higher capacity battery. The eQuinox is the current entry level Unistellar telescope. The eVscope 2 is still sold as the only model with the Nikon viewing port.

The two higher end models currently sold are the eVscope 2 and the eQuinox 2. **Table 1** compares the models.

Image 1 shows the eQuinox 2 packaged in its double-layered cardboard box. The telescope comes with a rugged lightweight tripod. The 4.4-pound tripod is a high-end photo-type tripod that is 21.5 inches when completely collapsed. When fully extended, the tripod is 41 inches tall. The top of the tripod (**Image 2**) has two clamps to secure the telescope/mount assembly. There is a bubble level on top of the tripod head. The tripod should be leveled before attaching the telescope, as the telescope will obscure views of the bubble level. It's essential that the tripod is level for the telescope to easily find objects. The tripod handles the telescope weight nicely and seems very stable.

Image 3 shows the telescope attached to the tripod. The complete set up takes just a couple of minutes. When I use the telescope, I do not deploy the lower extensions on the tripod legs. Since the telescope does not have an eyepiece, there is no need to have it at its maximum height to use it.

Notice in Image 3, the telescope is plugged into the wall. **Image 4** shows a closer view of where the power cord plugs into the telescope, below the on/off button. Plugging the telescope into the wall charges its internal battery. The telescope can be used while charging.

Similar to a laptop computer battery, the Unistellar manual states the eQuinox 2 should last from 2-10 years, depending on use. Like a laptop computer, if the battery dies, it can still be used plugged in. The original Unistellar manual stated the battery cannot be replaced by the user, but did not state what to do when it dies.

The current manual states "the bat-

Feature	eVscope 2	eQuinox 2
Aperture (mm)	114	114
Focal Length (mm)	450	450
Nikon "Eyepiece"	Yes	No
Advertised camera (MPx)	7.7	6.2
Camera FOV (arcmin)	34x47	34x47
Estimated battery life (hour)	9	11
Weight (lbs)	20	20
Price Summer 2023	$4,899	$2,499

Table 1 - A comparison between the Unistellar eVscope 2 and the eQuinox 2

Image 1 – The Equinox 2 came nicely packaged in Styrofoam in a double-layered cardboard box. The telescope came perfectly collimated and was almost perfectly focused out of the box.

Image 2 – The tripod has a bubble level and two thumbscrews that securely hold the telescope in place.

tery should not be removed by the user without prior inspection by Unistellar." When I emailed Unistellar and asked them what to do when the battery dies they replied "In that case, we can sell a replacement battery and provide instructions on installation. No telescope will be left behind! You would just need to contact support and talk to them about getting that replacement." They appear to now realize battery replacement is an issue for potential owners and they are trying to address that.

There is only one button on the mount, the afore mentioned power button. The power button lights up purple when depressed. After the onboard computer boots and the onboard Wi-Fi launches, the power button turns red, indicating the scope is ready to be used. The power is shut off by depressing the same switch, or via the software. In the software, a user can shut off the power, or command the telescope to park (position in Image 3) and then power down.

The telescope must be controlled using an Apple iOS device such as an iPhone or iPad, or an Android phone or tablet. I have an iPhone and iPad, so I only used those devices. I downloaded the Unistellar App onto both my devices from the Apple store. The software version at the time of this article was version 2.4. This version is much improved over version 1.0 and 2.1 that I used with the eVscope 2 in my previous review. I don't know all the changes made in each upgrade and have encouraged Unistellar to publish a list of improvements made with each software release.

The Unistellar's website has well-made videos on setting up and operating the telescope. Other videos produced by end users can be found on YouTube.

When the software is launched for the first time on an iPhone or iPad, there are some questions it asks to set the software up. If the questions are not answered properly, the telescope won't work with either device. Plus, there are no options in the app's settings to go back and re-address those setup options. So, if the software is not set up properly the first time, the app must be deleted and reinstalled to get it right.

Specifically when setting up the software, it will ask to use geolocator services on the device. This must be selected so the telescope knows where it is located. The telescope gets its location and the current time from the iOS device. This must be accepted. The second thing it asked was "Unistellar would like to find and connect to devices on your local network". This is necessary for the software to connect to the telescopes Wi-Fi broadcast though the phone or tablet. Finally, it asks to have access to the device's photo library. This is necessary to save images.

To start using the telescope after it is set up and powered on, connect the phone or tablet to the telescopes Wi-Fi broadcast and

Image 3 – The telescope and tripod can be set up in minutes. The internal battery should be charged before first use. When the phone or tablet is connected to the telescope's Wi-Fi broadcast, a battery level indicator is found in the telescope settings menu.

launch the Unistellar software. Once connected the camera image is displayed on the device.

The inside of the optical tube assembly is shown in **Image 5**. The 144mm f/3.95 mirror is in the back and the camera assembly in the front held on by a four-vane spider. The four vanes are wider than most Newtonian telescopes of the same size. This is because they are made of plastic and need to be wider to provide the same support as metal spiders in other Newtonians.

Image 6 captures a view of the imaging sensor housed inside of the secondary assembly. Like the eVscope2, the sensor is likely the Sony IMX347. The Sony IMX347 sensor is an array of 2688 x 1520 pixels, each pixel 2.9 microns(μm) on edge, for a total of 4.09Mpx. These pixels form a 16:9 array. This ratio seems to match the chip dimensions shown in Image 6. The images produced by the camera, viewed on the user's phone or tablet, are displayed in a four to three ratio (4:3). So, the images are being cropped by the telescope's processor. This may explain why there is very little coma seen on images as the corners where coma would the greatest are cropped out.

Unistellar told me the telescope has a resolution of 1.33 arcsec per pixel and the camera has a field of view of 47 x 32 arc minutes. Using the standard formula relating resolution to focal length and pixel size yields a pixel size of 2.9 microns (mm), consistent with the IMX347 sensor. Using the formula relating field of view to pixel dimensions tells us the 47 x 32 arc minute field of view is produced by 2120 x 1533 pixels.

Thus the IMX347 chip is being cropped from 4.09 to 3.23 Mpx to produce the 4:3 dimension images. The eQuinox 2 images saved by the Unistellar software onto my iPad have pixel dimensions of 2880 x 2160 (4:3) for a total of 6.2Mpx (see Table 1). Presumably, the Unistellar software is resampling the images to produce more pixels. I am not sure why as this does not increase the resolution of the images.

When the equinox is first set up, it needs to be focused. The telescope comes with a Bahtinov mask (**Image 7**) to aid in focusing. The focuser is a large hand knob on the bottom of the optical tube assembly (OTA) that operates by moving the primary mirror up and down. To use the mask, center a bright star in the telescope's field of view and turn the focuser until a symmetric star pattern appears on the image screen (**Image 8**). There is no image shift dur-

Image 4 – A close up of the power button and where the charging cable attaches to the bottom of the single-arm fork mount.

ing focusing. The telescope came perfectly collimated and has held the collimation from day one. If necessary, the mirror can be collimated with Allen wrenches following the procedure in the user manual.

The Unistellar software has a database of 37 million stars and more than 5000 deep space objects. Objects can be selected from a menu that can be filtered by object type or by searching using a catalog name (e.g. M42, NGC7221, Saturn, Moon). The telescope can also be slewed manually using a joystick on the phone or tablet screen. There is a slow motion slewing rate for centering objects already in the field of view.

The biggest strength of this telescope is the ease of use. You just take it outside, take off the cover and turn it on. Linking a phone or tablet to the telescopes Wi-Fi and launching the Unistellar app starts the star gazing process. The telescope should be manually slewed to a star region about 45 degrees elevation so it can capture stars and orient itself. It does this by comparing stars in its field of view to its star database.

When an object is selected for viewing, the telescope with slew to the object. It will take an image, sample the field of view and slew again to get the object onto the camera. Another photo is taken and the motors then center the object.

In the settings, one can select location type: city, suburbs, or rural. This is important so the processor can properly process the images on the screen. There is also a sensor calibration routing that takes a minute or two to run. The cover must be placed on the telescope to run this calibration. It is essentially taking and averaging a series of dark frames. This will improve the displayed or saved image quality. The calibration should be done whenever the temperature outside has varied by 10 degrees (F) since the last calibration was performed.

After an object is centered, the enhanced vision button should be pressed. That is the button with the three stars on it on the bottom of **Image 9**. This will start the camera capturing 4s exposures which are calibrated, registered, and stacked (added together) in real time on the screen. Within a minute or so, a detailed image of the object appears on the screen. Pressing the button again stops the integration and saves the image to the devices photo library.

Up to ten phones or tables can connect to the telescope's Wi-Fi simultaneously. One person is the telescope operator and the others are just observers that see the same screen images as the operator. You don't have to be outside with the telescope to view the images as long as you are still in range of the Wi-Fi. I place the telescope in my back yard and sit on my family room sofa, away from the summer mosquitoes or frigid winters to use it. I have even connected my iPad to my smart TV using Bluetooth to mirror the iPad onto my large flat screen for an entire room of people to observe with me.

Image 5 – This view shows the one-arm fork mount and the inside of the OTA.

To illustrate how simple this telescope is to use, examine **Image 10**. On the top left is an image of M22 I took from a dark site in Hawaii using a 4-inch refractor on a German equatorial mount. To take the image I had to set up the telescope and mount, polar align it, attach the camera and take dark and flat images. Then, when it was dark enough, I slewed it to M22 and captured eight five-minute exposures. Afterwards, I calibrated, registered and stacked the images on my computer to produce the final result. The total time spent was approximately three hours (set up, tear down and processing images). Total cost of equipment used to capture this image $7000, not counting

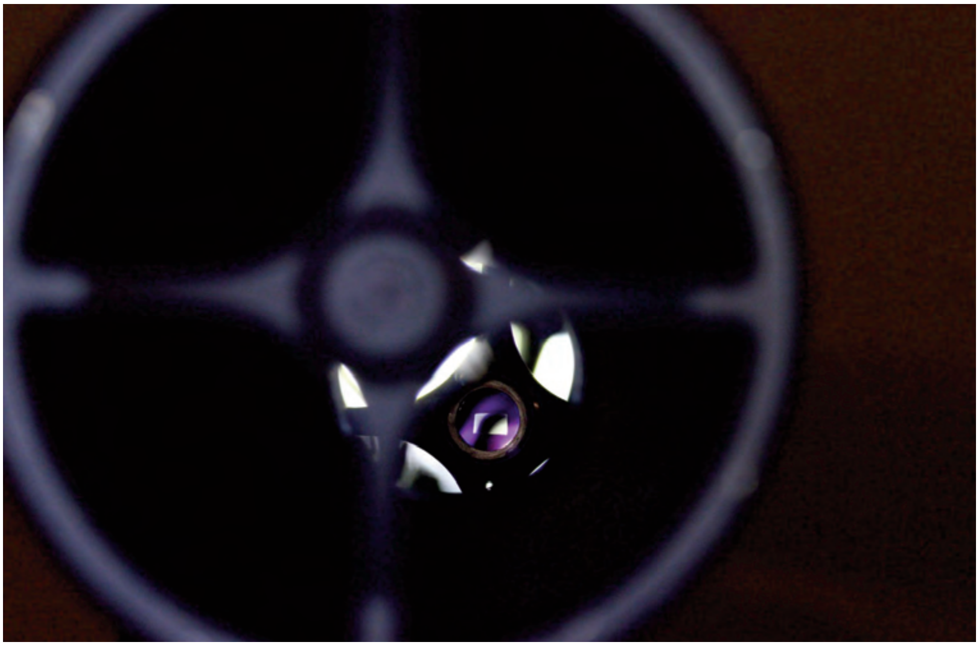

Image 6 – The camera resides inside the secondary assembly. The digital sensor is captured in a reflection in the primary mirror. It is unclear what the glass in front of the sensor corrects, if anything.

Image 7 – The telescope comes with a Bahtinov mask to aid in focusing.

the computer and software I used to process it and the cost of getting to a dark site in Hawaii!

The bottom image of Image 10 was taken with the $2500 Unistellar eQuinox. Set up time was five minutes. Tear down time was three minutes. Image acquisition time three minutes. Processing time five minutes because I rotated the image in Photoshop to make the two line up with north at the top of the images. The Unistellar image was taken in bright suburban skies in my back yard. They look virtually identical. Zooming in of the two images shows the refractor has much rounder and sharper stars than the Unistellar. But this is at a much higher investment of money and time!

Image 11 shows two images of the Moon I took on the same night in my backyard. One with a 110mm refractor with my Canon 600D camera, and the other with the eQuinox 2. The refractor was on a Celestron CGEM II mount and the set-up time for it was substantially longer than the eQuinox 2. The Canon picked up more color than the eQuinox 2 and the refractor had better resolution, but many people would be very happy obtaining this Moon image with such an easy-to-use Unistellar telescope. My investment in the equipment capturing the image on the right was more than $4500.

Images 12-17 show other objects I captured with the eQuinox 2 in suburban skies with just a few minutes exposure for each. The telescope is perfect for someone who doesn't want to drive to dark sites and set up complicated equipment. The eQuinox 2 opens up the whole universe to people in light polluted skies to be able to see celestial objects in detail that could not be achieved in those skies looking through the eyepiece of a similar sized telescope. ATT

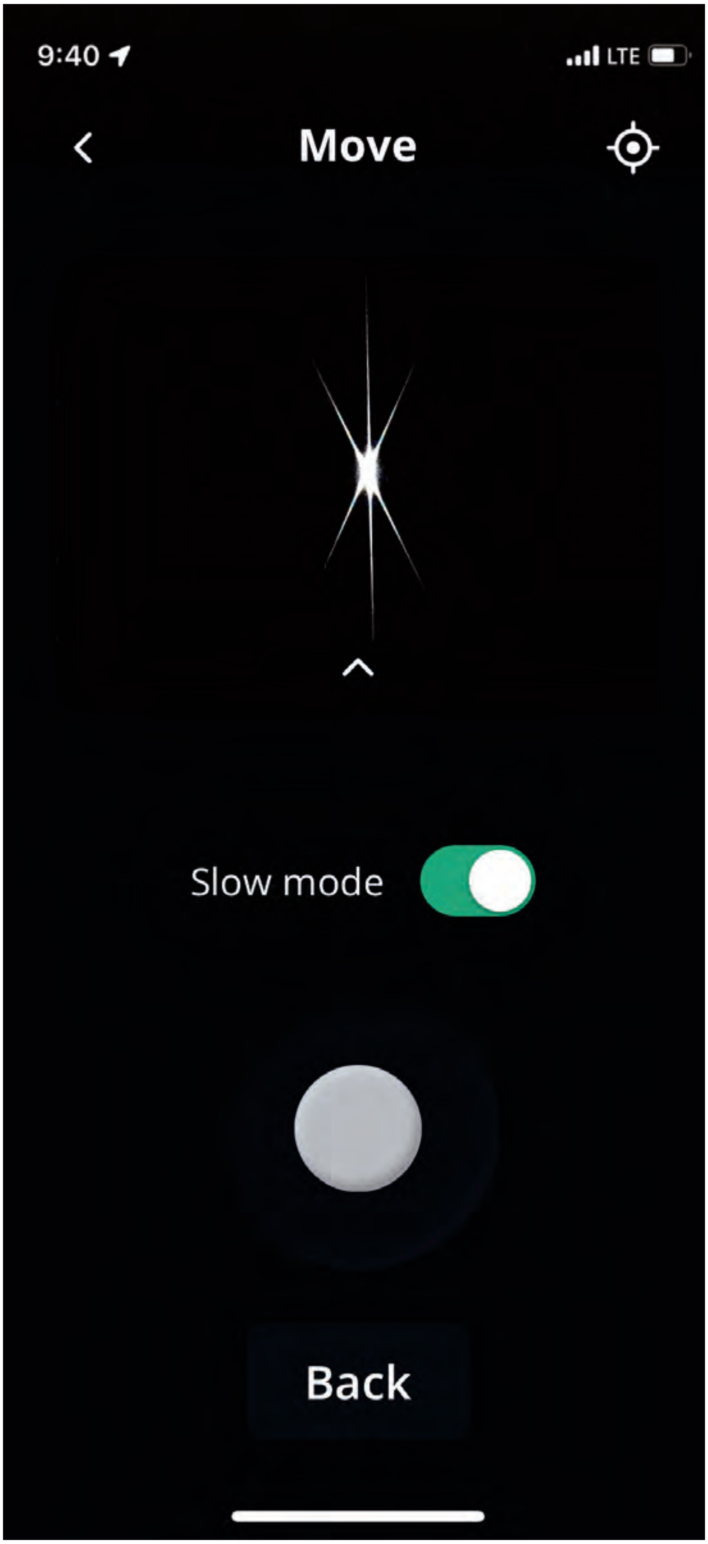

Image 8 – A view of a centered, focused, bright star on the camera display using an iPhone with the Bahtinov mask.

Image 9 – A view of M31, the Andromeda Galaxy, on the screen before enhanced vision is turned on.

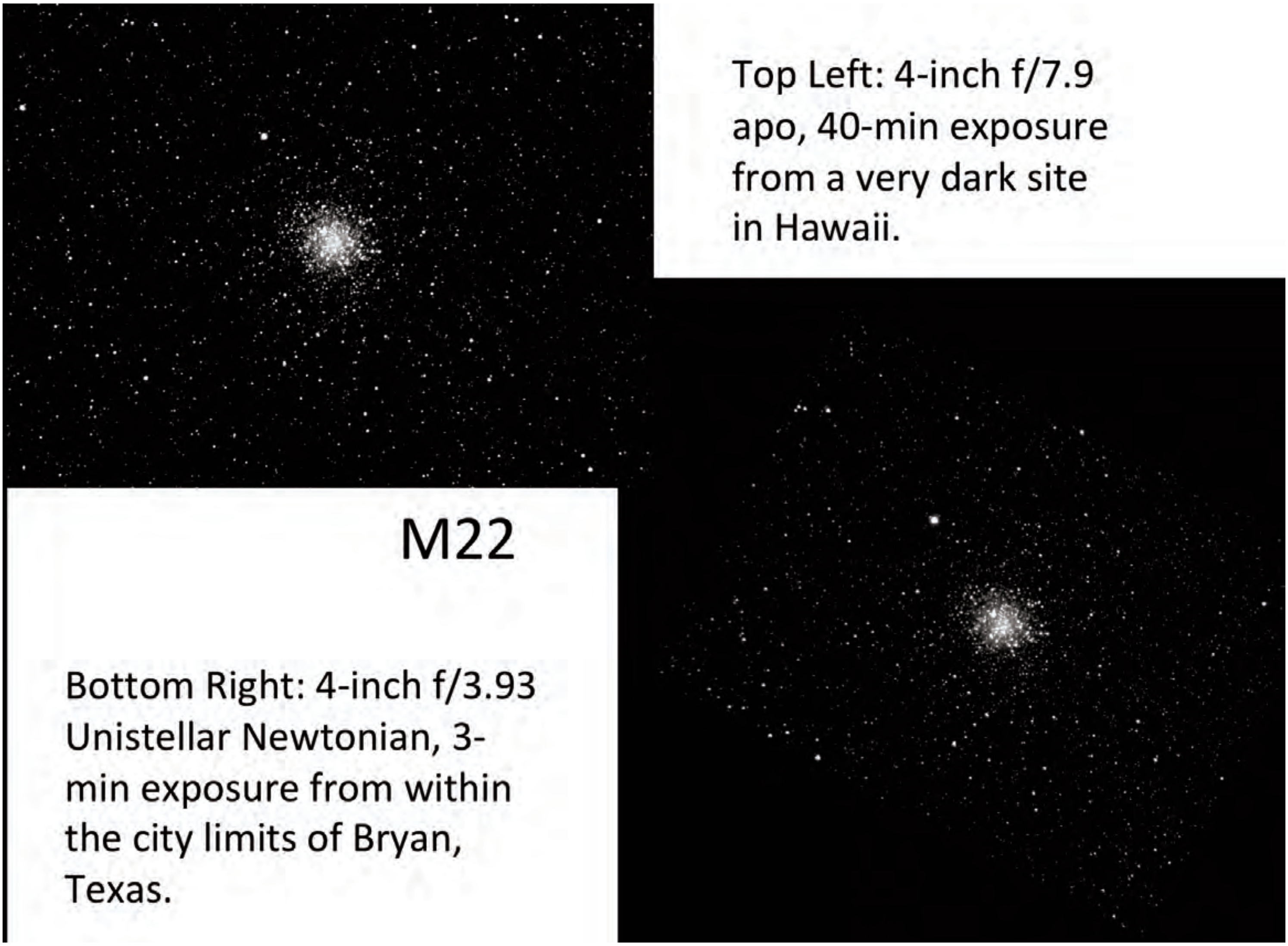

Image 10 – A comparison of M22 taken with the 114mm eQuinox 2 and a 102mm high-end apochromatic refractor.

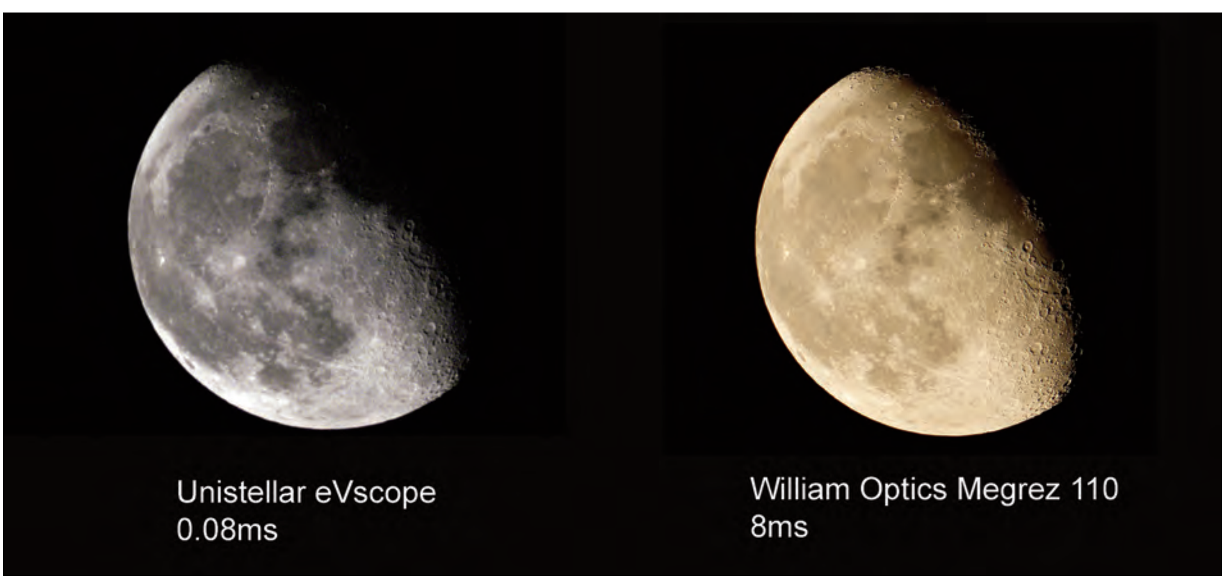

Image 11 – A comparison of the Moon taken the same night with the eQuinox 2 and a 110mm refractor.

Image 12 – A picture of globular cluster M13 with two minutes of enhanced vision (a.k.a. two minutes of stacked and processed 4s exposures).

Image 13 – The Lagoon Nebula (M8) captured with the eQuinox 2 in suburban skies with a 10-minute exposure. Note the red colors from the nebula. This amount of nebula detail and no color could never be seen in an eyepiece from the same suburban skies.

Image 14 – The Eagle Nebula (M16) captured with a 15-minute exposure.

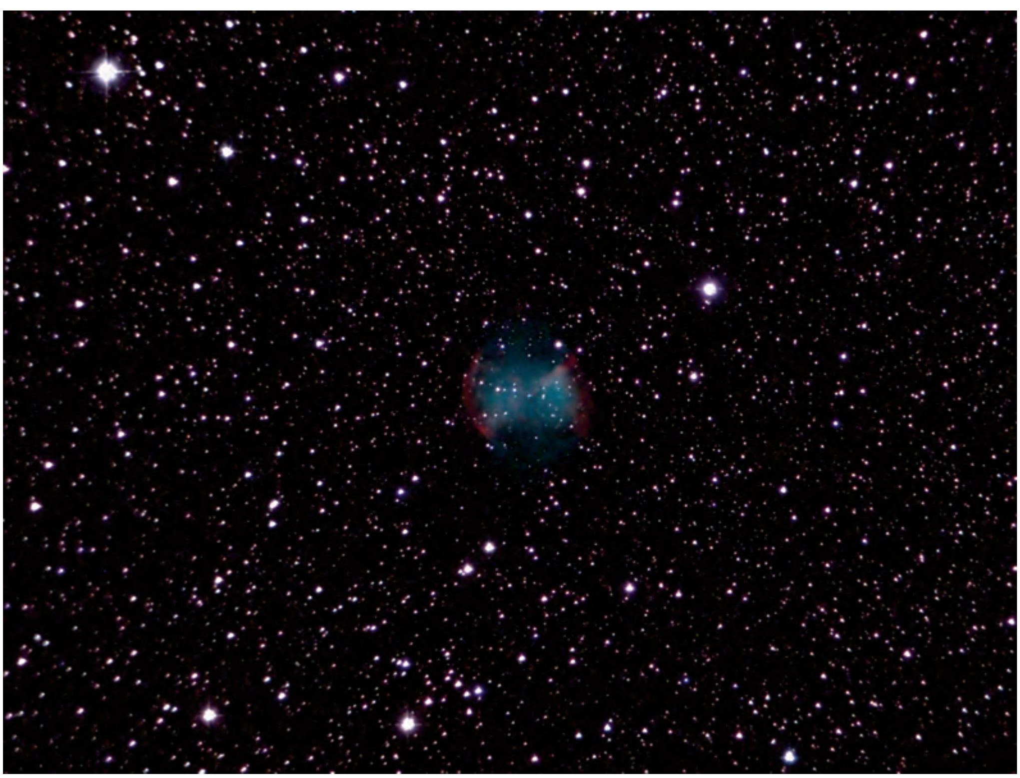

Image 15 – The Dumbbell Nebula (M27) captured with a 15-minute exposure.

Image 16 – Some spiral structure in NGC7331, the Deerlick Galaxy, after ten minutes of enhanced vision with the Equinox 2.

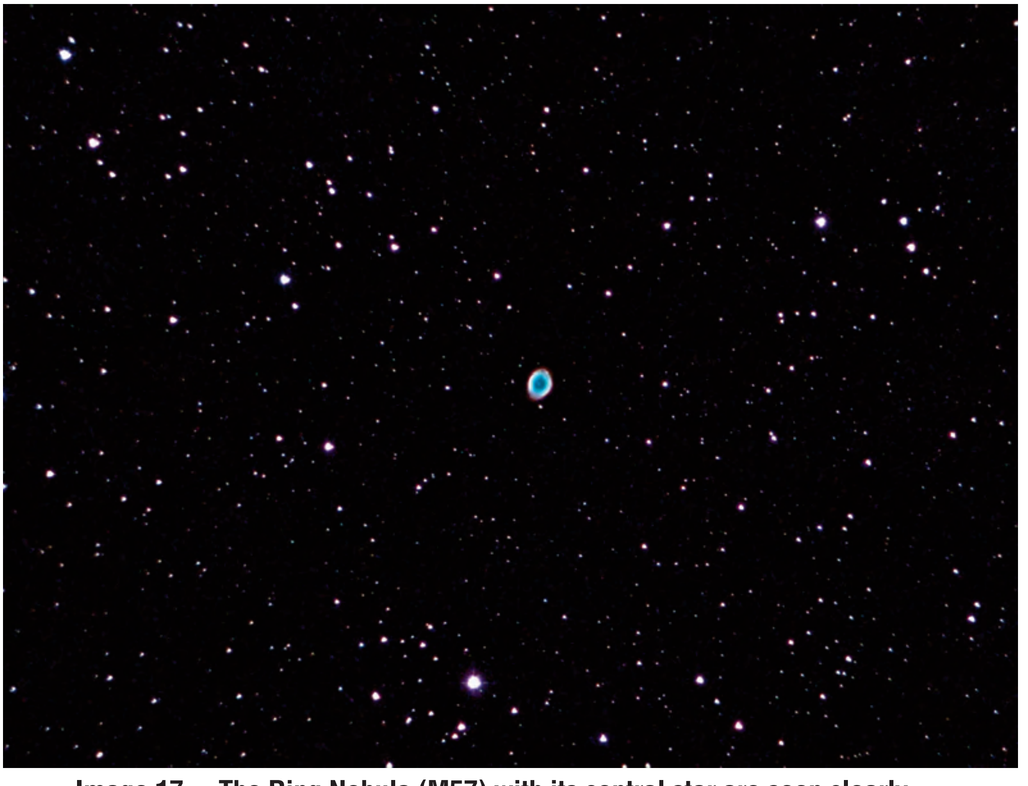

Image 17 – The Ring Nebula (M57) with its central star are seen clearly with only 60 seconds of enhanced vision with the eQuinox 2 telescope.