

# ASTRONOMY

## TECHNOLOGY TODAY

Your Complete Guide to Astronomical Equipment

COMPARING H- $\alpha$  FILTERS – FROM WIDE TO NARROW • OBJECT VISIBILITY - WHY CAN'T I SEE IT?  
CELESTRON STARSense EXPLORER TELESCOPES • INDUSTRY NEWS • NEW PRODUCTS

# THE CELESTRON STARSense AUTOGUIDER



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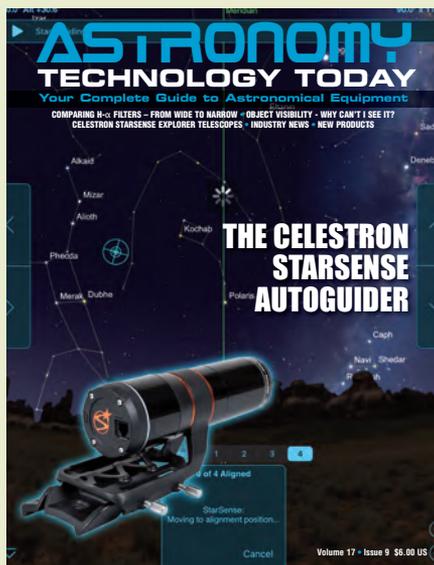
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In this issue Dr. Jame Dire shows the versatility of the StarSense Autoguider which can automatically perform a mount model for a Celestron mount, precisely center an object in an eyepiece or camera, and accurately autoguide a mount for long exposure astrophotography.



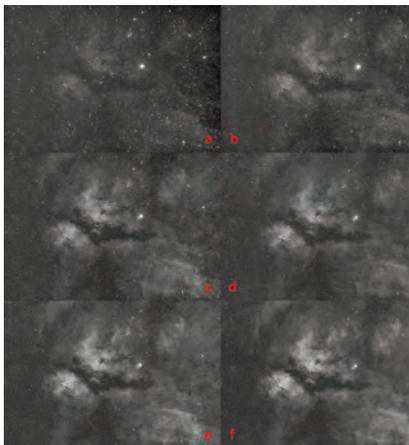
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**Dr. James Dire** has a M.S. degree in physics from the University of Central Florida and M.A. and Ph.D. degrees from The Johns Hopkins University, both in planetary science. He has been a professor of chemistry, physics and astronomy and an administrator 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.



**Jim Thompson** is an Aerospace Engineer in Canada who hosts the Abby Road Observatory website (<http://karmalimbo.com/aro/>) where he documents his journey with amateur astronomy. He got involved in video astronomy in part to share his passion for astronomy with his son and family. Here he documents his thought process on how to get started in astro video and the benefits of this emerging technology.



**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.

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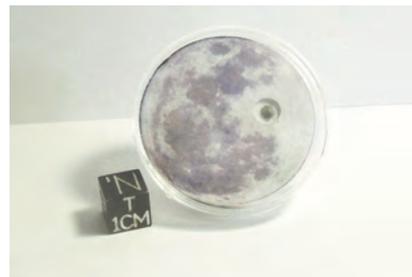


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# THE CELESTRON STARSENSE AUTOGUIDER

By Dr. James R. Dire

I can't think of another telescope company that has better name recognition among amateur and professional astronomers than Celestron. Celestron has been a leader in innovation in telescopes and accessories for more than half a century.

I have had just about every Celestron Schmidt Cassegrain telescope at some point in my life, from the C-5 to the C-14. I have also owned no less than six models of Celestron German equatorial mounts over the past three decades. The products keep getting better and better.

I reviewed their first StarSense Explorer telescopes (That article is available on page 87 of this issue). The simplicity of the phone adapter was impressive enough. But the real wow factor was the software. It can turn any telescope into a GOTO system without the cost of an expensive telescope mount.

Now Celestron has come out with the StarSense Autoguider (**Image 1**). This device has impressed me just as much as the StarSense Explorer telescopes did. Again, it's not so much the hardware that was innovative. What

blows me away is the software that controls it to easily do so many useful things.

The StarSense Autoguider can automatically perform a mount model for a Celestron mount, precisely center an object in an eyepiece or camera, and accurately autoguide a mount for long exposure astrophotography.

There are three ways to control the StarSense Autoguider. One is through

the telescope's hand controller. The second is to connect to the telescope wirelessly using the Celestron SkyPortal app and control it using a smart phone or tablet. The final way is to connect to the telescope using the Celestron Plane Wave Instrument (CPWI) software on a computer. I tested the StarSense Autoguider using the first two methods.

The StarSense Autoguider works



**Image 1** – The StarSense Autoguider will align Celestron mounts, center object in the telescope and guide during imaging.

## THE CELESTRON STARSense AUTOGUIDER



**Image 2** – The device comes with an instruction manual, tools and two mounting systems.



**Image 3** – The author attached the StarSense Autoguider to an Orion-style dovetail mount and attached it to the finder shoe on a small refractor.

with all current Celestron equatorial mounts. These include the AVX, CGX series and the CGEM II. It will also work with older mounts such as the CGE, CGE Pro, the CGEM and the CGEM-DX, which are no longer sold. Since I currently use a CGEM-DX, a

CGEM II and an AVX, I tested the StarSense Autoguider with all three mounts.

The StarSense Autoguider comes with an instruction manual, two mounting systems and some tools to swap them out (**Image 2**). One mount-

ing system is designed to attach the StarSense Autoguider to a Celestron Schmidt Cassegrain telescope. The StarSense Autoguider came with that system already attached to it. The other mounting system is a bracket that fits Orion-style finder shoes. Since that is how I needed to attach it to my telescopes, I performed the simple swap using the included instructions and tools. The swap out took under 10 minutes.

**Image 3** shows the StarSense Autoguider attached to the tube rings of a 110mm refractor on a Celestron AVX mount. A close up view of the unit appears in **Image 4**. The back of the StarSense Autoguider is pictured in **Image 5**. There are two ports on the back. The port that looks like a phone jack is where the auxiliary cable connects to the unit. The other end of this cable must be connected to the AUX port on the mount. The cable is shown attached in **Image 4**. The telescope communicates with the mount through this connection.

The other port on the back of the StarSense Autoguider is for connecting a USB cable to the unit to update the software. This cable is not included. You can also update the software through the telescope when the auxiliary cable is attached and the telescope's hand controller is connected to a computer using a USB cable. Either way a USB cable needs to connect to a computer running Celestron Firmware Manager (CFM) software to upgrade the StarSense Autoguider software.

The StarSense Autoguider features a high-quality 4-element double gauss optical system (**Image 6**). Its unique design delivers sharper images than other mini-guide scopes. The aperture

## THE CELESTRON STARSENSE AUTOGUIDER



Image 4 – A close up view of the StarSense Autoguider.



Image 5 – The back of the StarSense Autoguider has two ports. One for connecting an auxiliary cable to the mount and one for connecting a USB cable to a computer to upgrade its firmware

is 28mm, smaller than a 50mm finder, but more than ample for the task!

The focal length is 120mm making it an  $f/4.3$  system. This fast, short-focal-length optical system allows the

StarSense Autoguider to see a wide field of view to find alignment stars and orient itself. The optical tube is threaded to accept 2" astronomical filters.

The device also includes an on-board computer and a highly sensitive Sony IMX290-DLL monochrome CMOS image sensor, all-working together to provide exceptional guiding accuracy. The sensor has a diagonal of 6.46mm with  $2.9\mu\text{m} \times 2.9\mu\text{m}$  pixels. It has a total of 2.1 megapixels. I calculate the field of view of the camera to be 2.66 degrees  $\times$  1.50 degrees. You can view a live image from the camera via your PC using the free Celestron Plane Wave Instruments (CPWI) control software.

The StarSense Autoguider's on-board computer has two core processors, a graphics processor unit (GPU), 512MB of RAM, and 4GB of ROM. This is more than enough processing power for the job. Everything is conveniently packaged inside the unit. All of the electrics are powered through the auxiliary port connection to the telescope!

My first night using the StarSense Autoguider, I attached it to a 110mm  $f/5.95$  refractor on a Celestron CGEM II mount. I attached a diagonal with a 14mm  $82^\circ$  field of view eyepiece to the telescope. I locked the StarSense Autoguider to the finder shoe on the front tube ring (Image 7). A red dot finder was attached the other tube ring. I only had to use it once.

I controlled the telescope with Celestron SkyPortal software on an iPad through a Celestron SkyPortal WiFi module plugged into the mount's hand controller port in lieu of the hand controller itself (Image 8). Once the SkyPortal was connected to the telescope, the screen pictured in Image 9 appeared asking to initiate the telescope alignment. When align was selected, the telescope began slewing to and acquiring alignment stars

## THE CELESTRON STARSense AUTOGUIDER



**Image 6** – This view shows the StarSense Autoguider's optics.

(Image 10).

No interaction with the telescope or SkyPortal software was required during

the alignment procedure. The StarSense Autoguider acquired two alignment stars on the west side of

the meridian, followed by two alignment stars on the east side of the meridian. When the alignment is complete the screen may look something like **Image 11**.

Once the alignment is complete it is necessary to calibrate the StarSense Autoguider so that it can precisely center objects in the eyepiece. This only has to be done once during the night. The procedure requires selecting a star for the telescope to slew to. Once the slewing stops the star must be centered in the eyepiece using the slewing buttons on the software. I used my red dot finder to get the selected star into the eyepiece and viewed through the eyepiece until I exactly centered the star. Next I pressed the alignment button at the bottom of the screen (Image 11) to complete the calibration of the StarSense Autoguider.

For the rest of my observing

An advertisement for StarSync Trackers. The background is a night sky view through a telescope, showing a large, bright object (likely the moon) and a field of stars. A red cylindrical component of the tracker is visible in the bottom right corner. Overlaid text includes:

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session, the StarSense Autoguider automatically centered any object in the eyepiece that I selected on the SkyPortal app. Observing couldn't get any easier!

I didn't do any imaging my first night testing the StarSense Autoguider. But notice the "Start Guiding" button at the top of the screen in Image 11. If I had pressed this button, the StarSense Autoguider would have calibrated the mount for guiding and then starting a multi-star guiding session, allowing any camera attached to the telescope to take any length exposure.

**Image 12** shows where the StarSense Autoguider's settings are found in the SkyPortal software. Enabling Precise GOTO sets the StarSense Autoguider to take an image while zeroing in on an object to ensure it perfectly centers it for the telescope.

The StarSense Autoguider did an outstanding job of driving my telescope to selected objects and centering them in my eyepiece. This telescope had a 655mm focal length and I was using a 14mm eyepiece yielding



**Image 7 – Another close-up view of the StarSense Autoguider.**

47x magnification. Next I decided to test it using my 10-inch f/12 Cassegrain telescope, which has a 3044mm focal length. The same 14mm eyepiece provides a magnification of 218x.

**Image 13** shows the StarSense Autoguider attached to the 10-inch Cassegrain, itself on a Celestron

CGEM-DX mount. A side view of the equipment appears in **Image 14**. This night I decided to test the equipment using the telescope's hand controller.

My hand controller had not had a software upgrade in quite a while. So before heading out for the night, I connected my laptop to the hand controller (while it was connected to the

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**Image 8 – The StarSense Autoguider’s auxiliary cable should be attached to the AUX port on a Celestron mount. It can be controlled via a phone, tablet or computer using WiFi from a Celestron SkyPortal adapter shown here**

telescope and powered up) using a USB cable. I then ran the Celestron Firmware Manager software on the laptop to install the current version of the firmware. This version, shown in **Image 15**, contains the StarSense Autoguider software.

When I fired up the telescope, the first screen the StarSense Autoguider software brought up was asking to polar align the telescope (**Image 16**). Since I have a polar alignment scope on the mount and had already polar aligned it, I skipped this step. In the absence of a polar alignment scope or clear view of Polaris, the StarSense Autoguider will assist in polar aligning the mount. It’s polar alignment routine is much simpler to use than that on the hand controller without attaching a StarSense Autoguider.

After skipping the polar alignment routine, the hand controller went straight into the mount alignment

menu (**Image 17**). After selecting the default Auto Align, the mount started slewing to alignment stars while the StarSense Autoguider took images. During the alignment procedure, the hand controller displayed that the alignment was in progress (**Image 18**). After acquiring stars on both sides of the sky, the alignment was complete.

This was so much easier than manually finding my own alignment stars and centering them in an eyepiece!

The last step to setting up the telescope for the observing session was to calibrate the StarSense Autoguider to the eyepiece. This starts with finding the StarSense Autoguider (SSAG) menu on the hand controller (**Image 19**) and selecting the calibrate menu (**Image 20**). This routine, similar to the calibration with the SkyPortal software, require me to select a star to slew to. Once the telescope slewed

to the star, I had to use the hand controller to center the star in the eyepiece. This was the only time during the night I had to touch the slewing arrows on the hand controller or use my red dot finder

Despite the enormous focal length of the telescope and the fact I was using an eyepiece that provided 218x, the StarSense Autoguider put every object I called up on the hand controller in the center of the eyepiece! This allowed me to view many more objects per hour than I could otherwise.

My last test for the StarSense Autoguider involved using it as an actual autoguider.

For this, I attached it to a 70mm f/6 triplet refractor with a field flattener and a CCD camera onto a Celestron AVX mount (**Image 21**). I set the equipment up in my backyard, polar aligned the telescope with the polar scope and did a star alignment with the StarSense Autoguider. I calibrated the StarSense Autoguider to the CCD camera the same way I previously did with an eyepiece. Then I slewed to the Great Hercules Globular Cluster, M13. The StarSense Autoguider had it centered on the CCD in one slew.

To guide with the StarSense Autoguider, I had to call up the SSAG menu on the hand controller (**Image 19**) and scroll to the guiding menu (**Image 22**). Once I selected guiding, the mount took a few minutes to calibrate the camera for guiding and then began multi-star guiding.

Normally, I would guide with a software package such as MaximDL. I would have to calibrate the guider in the software, select a guide star on the screen and command the software to star guiding. With the StarSense Autoguider, this was all automated without

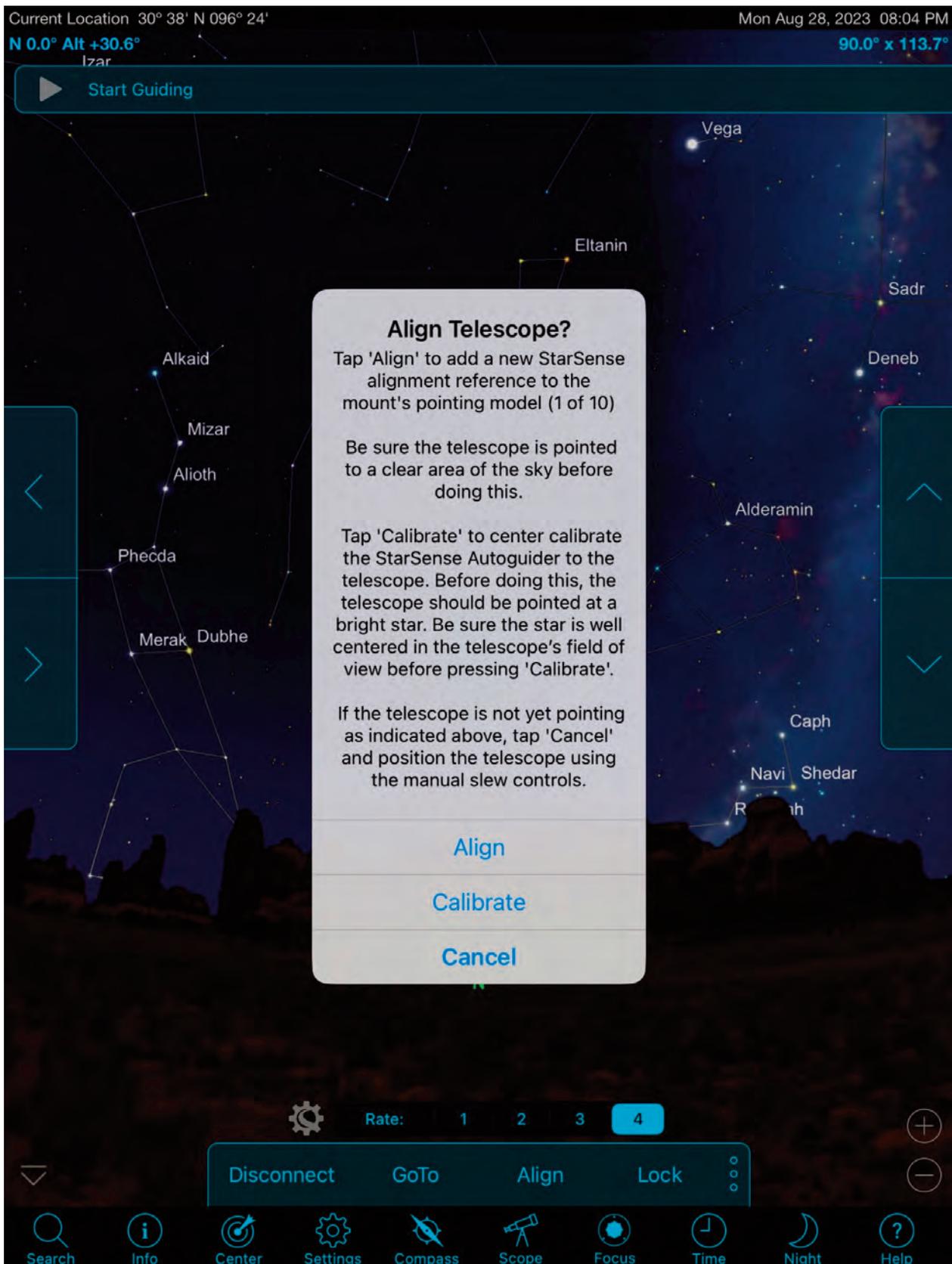


Image 9 – When connected to a phone or tablet running Celestron SkyPortal software, the StarSense Autoguider can perform an automatic star alignment for the mount.

any user input.

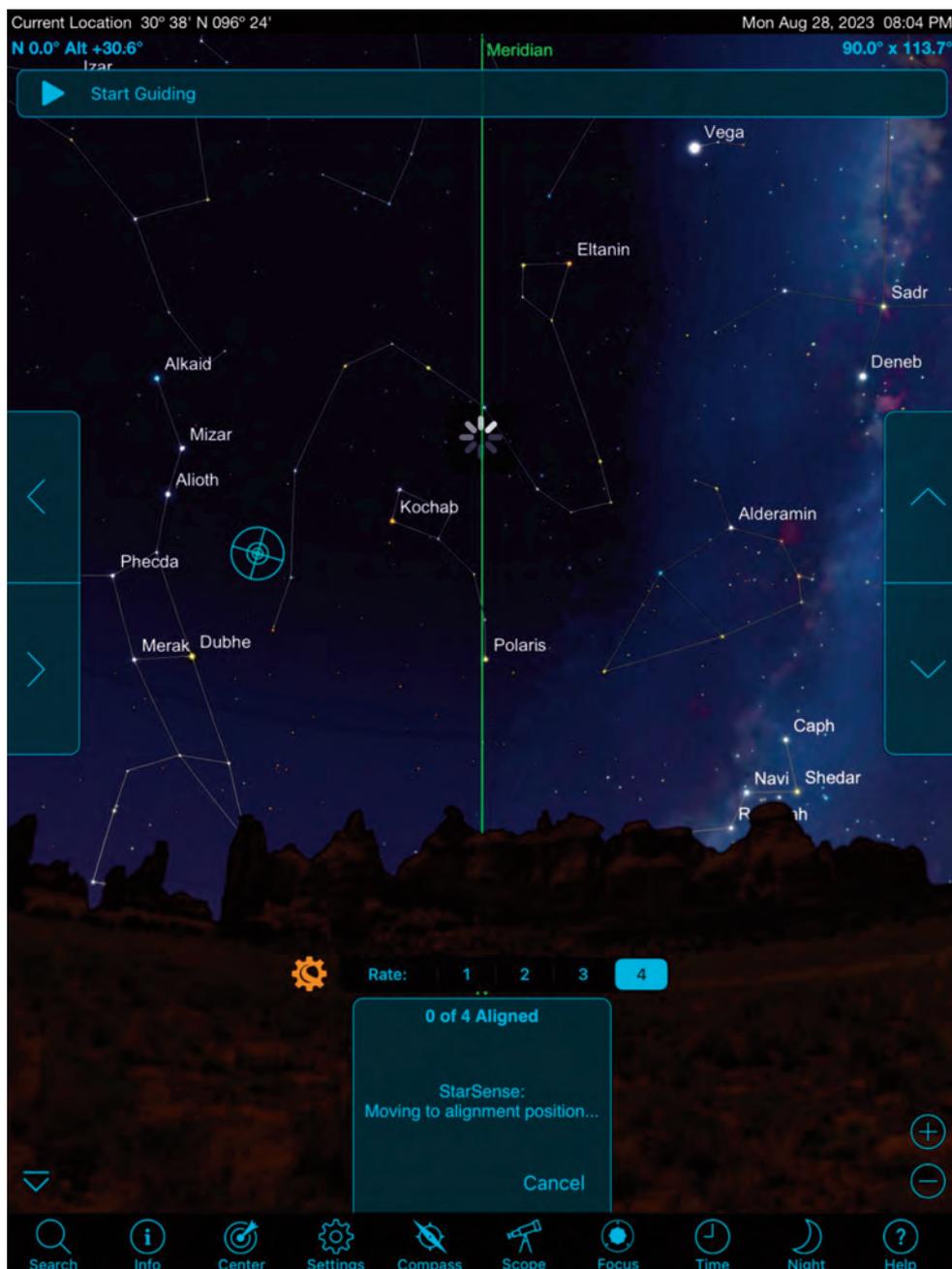
In MaximDL or similar software, a graph of the guiding error along each axis appears on the screen along with a running Root Mean Square (RMS) error for each axis. Using the StarSense Autoguider for guiding provides guiding information on the hand controller screen ((**Image 23**). The RMS guiding errors are displayed for both right ascension and declination in arc seconds. This is different from other guiding software where it is given in pixels. Errors in arc seconds make more sense because they are independent of the focal length of the telescope used!

As can be in Image 23, the guiding errors are excellent. The *s* number tells how many stars the StarSense Autoguider is using for guiding. Finally the *Q* number is a measurement of the atmospheric seeing. The numbers can range from 0 to 100, where 100 is perfect seeing. The *Q*=95 number in Image 23 tells me the seeing was excellent the night I tested the guider.

**Image 24** is the result of a 15-minute exposure of M13. All of the stars are pinpoint and round. I could not have achieved better results using any other method for guiding!

I could only find one weakness of using the StarSense Autoguider with my Celestron mounts. Since the mounts only have one AUX port (see Image 8), I cannot attach both the StarSense Autoguider and a Celestron external GPS. This meant when using the hand controller, I had to manually enter my location and time into the hand controller. The other option is to first connect the GPS to get the location and time, then turn off the mount and attached the StarSense Autoguider and then reboot the mount.

The benefits of using the StarSense



**Image 10** – The screen on an iPad while the StarSense Autoguider performs a mount alignment.

Autoguider far outweigh this minor inconvenience. And when using the StarSense Autoguider with the SkyPortal app on a phone or tablet, or with the CPWI software, the telescope gets the date and location from the phone, tablet or computer.

The StarSense Autoguider is an amazing device. It is exceedingly easy

it is to use and greatly simplifies setting up a telescope, finding and centering objects and autoguiding. It does all this with optics smaller in diameter than any of my finder or guide scopes! This device makes visual observing and imaging more efficient and fun. I don't know how I ever got by without it. **AM**

# THE CELESTRON STARSENSE AUTOGUIDER



Image 11 – After the mount alignment the SkyPortal software is ready to use.

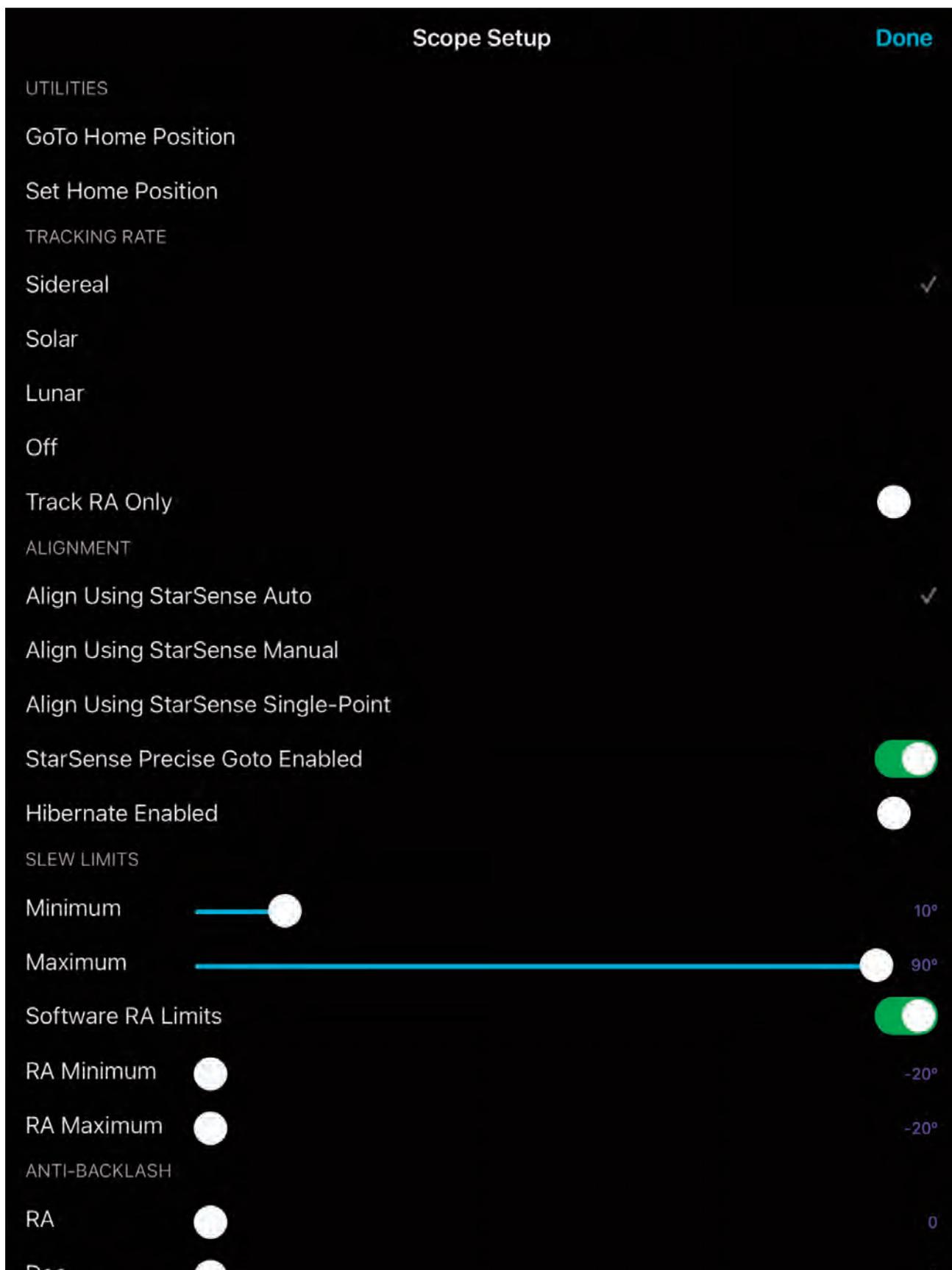


Image 12 – This view shows the StarSense Autoguider settings in the SkyPortal software.



**Image 12 – The author attached the StarSense Autoguider to a 10-inch f/12 classical Cassegrain on a Celestron CGEM-DX mount to test the GOTO capabilities with a long focal length instrument.ware.**

## THE CELESTRON STARSense AUTOGUIDER



Image 14 – Another view of the StarSense Autoguider, 10-inch Cassegrain telescope, and CGEM-DX mount.



Image 15 – The hand controller must have firmware version 5.35 or newer to work with the StarSense Autoguider.



Image 16 – With the StarSense Autoguider attached to the telescope, the first operation it tries to perform is a polar alignment of the mount.



Image 17 – After skipping or completing a polar alignment with the StarSense Autoguider, the next step is to use it to star align the mount.

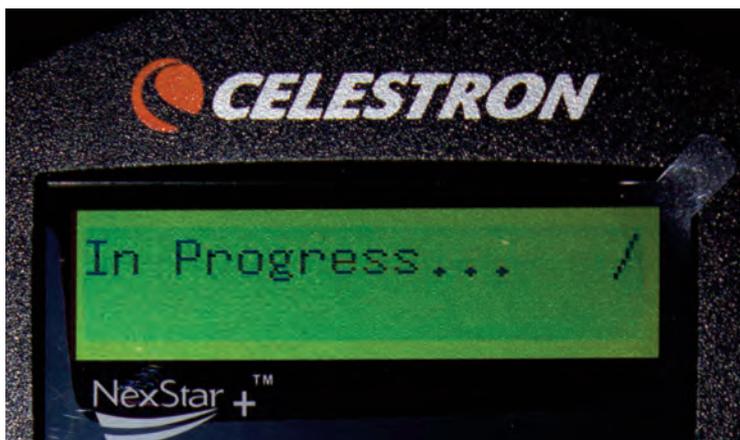


Image 18 – During a star alignment, the hand controller only displays this simple message.



Image 19 – The SSAG menu is used to access features of the StarSense Autoguider.

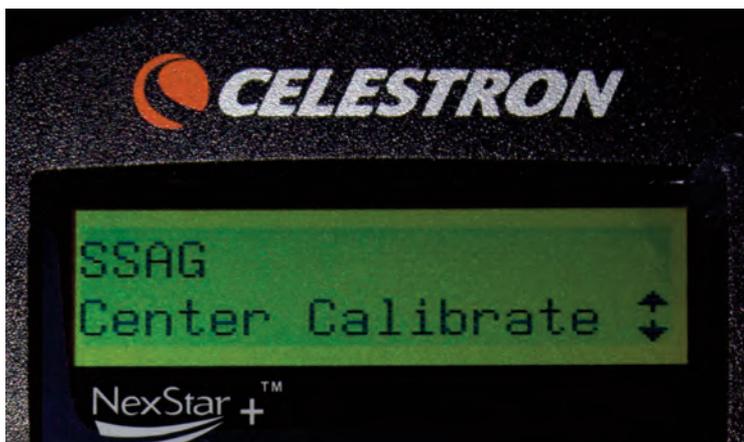


Image 20 – The Center Calibrate function allows the StarSense Autoguider to align with the center of the telescope's field of view.



Image 22 – To initiate guiding from the hand controller, use the guiding menu found under the SSAG menu.



Image 23 – Guiding RMS errors are displayed for both axes. The "s" number indicates 20 stars are used for guiding. The "Q" number rates the atmospheric seeing.



Image 21 – The author tested the auto guiding capabilities of the StarSense Autoguider using this telescope and camera setup.



**Image 24 – Globular cluster M13 captured with an SBIG ST-4000XCM CCD camera with Stellavue ST-70T refractor on a Celestron AVX mount. Guiding was done with the StarSense Autoguider.**