Imaging Tips

For Meade LX200 Users

April 27, 2009

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"The beautiful thing about science is that it can be tried, tested, proven and disproved. We don't have to keep on believing the same thing for the sake of tradition. Whether or not scientists are someday "proven" to be correct or wrong in their theories, they still provide a valuable reminder that questioning IS the basis for new discovery and for Science itself. "

I started using the SBIG ST-237A CCD camera in 2003. Armed with my wife's Dell laptop computer, I would head out to Tierra Del Sol on the weekends with my Meade 8" LX200 Classic SCT. I would always try getting there early enough to set everything up while still light. Setting up in "Polar Mode" was something new at the time and requires an Equatorial Wedge (see next paragraph). The LX200 starts its polar alignment procedure with the optical tube assembly (OTA) in an upside down orientation. This was kind of strange having the OTA in this orientation and what's kind of funny is I'm not the only one to feel this way. There's been numerous times that I've helped people that are new to Polar Aligning the LX200 and I get the same reaction from a lot of them.

An Equatorial Wedge is essential for setting up a fork mounted SCT for doing astrophotography. Even though the mount will track an object while set up in "Alt-Az" mode, you will get field rotation in the images. Setting the telescope on an equatorial wedge eliminates field rotation. I started with Meade's Standard Wedge, which is their low-end wedge. There are always problems with low-end merchandise and this wedge had plenty. Because it's so lightweight, it is not a very stable platform for astrophotography. The slightest bump or breeze would make the scope shake. It was very difficult to make minor adjustments as any adjustment would jump rather than move smoothly. I have since upgraded to, in my opinion, the best equatorial wedge made. That wedge is the Ulti-Wedge, Made by SDAA member, Randy Marsden. Visit his web site to see the specs and you'll understand why I feel this way at Pad 55 Products. NOTE - Randy has decided that he has to invest too much time to construct this wedge and no longer will produce this it. He would probably give up his drawings if you were to contruct one yourself.

You start polar alignment of the LX200 by doing several iterations between Polaris and the secondary alignment star. For in depth procedural instructions, see Philip Perkins discussion on how to do Iterative Method of Polar Alignment. After doing these iterations, it's time to start drift aligning. See Drift Alignment Procedures here. As I've said before in other pages on this site, this was the hardest thing for me to be successful at. Getting or not getting good polar alignment would determine whether I'd be successful that night in taking astronomy pictures or going home frustrated. More times than not, I went home frustrated, even after hours of drift aligning. But there were just enough times that I was successful to keep trying to get better.

In those early days of the learning curve, there really wasn't any support in learning from others. There were a few astro-imagers around to ask questions, but they didn't give up the answers easily. You had to ask the right questions to get at how to fix the problems. And since I was new to imaging, I didn't ask the question properly and didn't get the correct answer to make a step up in the learning curve. Since then, the Astro-Imagers-Special-Interest-Group (AISIG) has been formed within the SDAA. They get together once a month with a topic speaker specific to a facet of Astro-Imaging. The more advanced imagers take the time to share their knowledge with the less advanced imagers. Those early days really left an impression on me, as I'll now take the time to sit down, one on one with a beginner to show them what I've learned.

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"SYNC"ing the LX200 Classic

Now that everything is aligned, it's time to pick a target. Pointing the LX200 is pretty easy. I was running "TheSky" version 5, level II on my wife's laptop, which made it even easier. Putting that first object on the small 237 chip was sometimes difficult. Centering on a bright star with a well collimated Telrad usually put the star somewhere on the chip. It was then just a matter of putting the camera in focus mode with a short exposure to get a continuous update on the computer monitor and making small adjustments with the hand controller to center the star and performing a "Sync" function either with the hand controller or within TheSky software.

To perform the "Sync" function with an LX200 Classic hand controller, select one of the guide stars within the menu - Key: Star(6), ENTER, ENTER. This gives you the list of guide stars within the menu. Select the star that you are trying to center on and when you have the star centered on the CCD chip, PRESS AND HOLD the ENTER button till the hand controller beeps. The hand controller will read that you have synchronized on the object.

To perform a "Sync" function with TheSky, click on the star with in the program that you are centering on the CCD chip. The object information dialog box will appear. After making sure the star is centered on the CCD chip, click on the telescope tab and then click on the Sync button. The program will ask to confirm sync, click OK. Now that you have told the telescope and the software exactly where the telescope is pointing it's just a matter of slewing to an object by using the hand controller or the planetarium software. When slewing to a new object, the object is usually somewhere on the CCD chip and takes some minor adjustments to center the new object.

If the new object is in a different part of the night sky, sometimes the pointing accuracy is off enough where the object won't be seen on the CCD chip. Slew to a known star in the area and perform a "sync" operation as described above. This is where using a planetarium program with telescope control really comes in handy. There are only a limited number of named stars in the database within the LX200 hand controller, so using the software offers more choices to perform a sync. After performing the sync, simply slew to the object and it will be near the center of the chip. This is similar to using the "High Precision Pointing" function within the LX200 Hand box. The star should have been somewhat focused during the centering on the chip procedures. If it weren't it would be difficult to see the star on the screen. If the telrad were not collimated well, you would have to take the camera off the telescope and insert an eyepiece into the telescope and center the star. Then replace the camera and perform the procedures described above.

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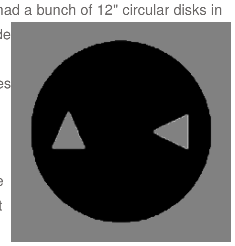
FOCUSING

With the Aid of a Focusing Mask

There are a couple of ways to focus using a CCD Camera. I've found that the use of a focusing mask makes the task a lot easier. Ron Wodaski's book, "The New CCD Astronomy" describes a several focusing aides. By the way, his book is a "must have" item for the CCD imager. The one that he describes in his book that I use is the Hartman Mask with two equilateral triangles off set to each other.

I made this mask out of ¼" sheet plastic that I picked up from a local plastic fabricator (http://www.ridoutplastics.com/). The have a so-called throwaway bin out in front of the building and sell its contents by the pound for a very reasonable price. It just happened that they had a bunch of 12" circular disks in the bin the day I stopped by to get materials for making the mask for my Meade 10" LX200. I believe the day I went by they had disks that fit the 8" also. That took a lot of the work out of the project, as all I had to do was draw the triangles and cut them out. I used a Saber Saw with a plastics blade to cut the triangle holes out of the disk. I attached three metal strips to the outside edges of the disk and bent them over perpendicular to the disk and covered them with Velcro loop (the fuzzy soft part of the Velcro strip). These strips are to hold the mask to the front of the telescope and the Velcro loop is a safety measure just in case I were to miss in the dark and hit the corrector plate with the metal strips while placing the mask over the front of the telescope. It also keeps them from scratching the side of the tube.



Choose a bright star and slew the telescope to the star. Center the star on the CCD chip. In CCDSoft, Connect to the Camera and go to the "Focus Tools" tab. Set the camera's exposure from .5 seconds to 1 second depending on the brightness of the star. Select the "Continuous" box, "Imager" and bin 2x2 or 3x3 for faster download times. Click the "Take Image" button. The camera will continually take an image and download it to the desktop giving you a refreshed image every couple of seconds. Place the mask over the front of the telescope. As the star comes into focus, there will be two triangle shaped stars on the screen that will get closer as the telescope comes to focus. When the two triangles get really close to each other you will see diffraction spikes start to appear off of each. When the two come together, you will see 12 of these spikes and when they all appear to come together at the same point, you are focused. To make sure that you are focused, go to the camera control dialog box and abort the imaging run. Change the binning to 1x1 and start a focusing run again. The image on the screen will be much larger now and will be easier to see if you are truly focused. You'll notice that download times are longer, which is why you don't do the initial focus binned 1x1.

The animation below illustrates how this mask works and what you will see. Notice that the triangles come together, the diffraction spikes appear and then all point at the same point. You'll notice that I went past the focus point and then came back to the focus point.

Animation: Focusing with the Triangle Hartman Mask

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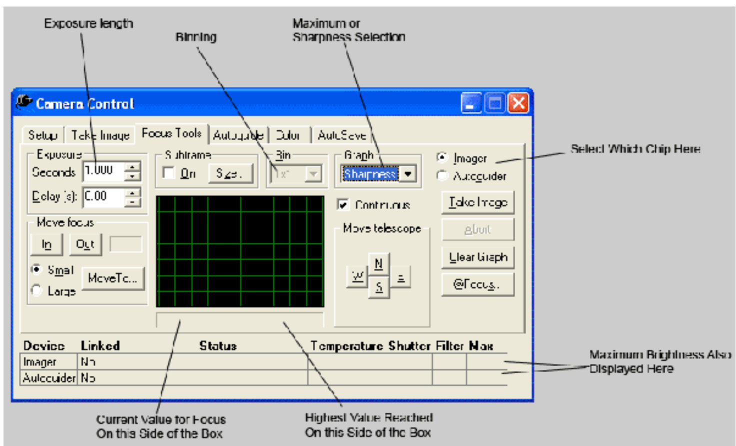
Focusing with the Aid of CCDSoft

Another way to focus is by using software; I use CCDSoft V5. For this, choose a dim star probably around magnitude 10-12. In CCDSoft, go to Camera, Setup and connect to the camera. Click on the Focus Tools tab. Select the imager as the chip you will use to focus with. Depending on the brightness of the star that you are using to focus, set the exposure time to about 1 second. Again bin 3x3 for a faster download and update to the computer's screen. If the star is badly out of focus, you will see a donut on the screen. As you adjust the focus on the telescope, the donut will get small and smaller until the dark center disappears. Continue to focus in the same direction until the star gets to its smallest point.

In the Camera Control dialog box under the Focus Tools tab you will see a graph showing you either the highest maximum or sharpness depending on which is selected. I've found that which I select depends on the seeing conditions. If seeing is really good it's better to select maximum and if seeing is average, select sharpness. While the camera is still cycling through focus frames, adjust the focus of the telescope to the highest number value located just below the graph. The value shown below the graph will show you the current value as well as the highest, which makes it easier to keep track of. I will roll it past the highest value and then come back to make sure I've reach that highest value. If you've selected sharpness, you can also see the maximum value at the same time as it's value is also shown in the box in the lower right corner of the Camera Control dialog box. I use both of these methods to focus. I first use the focusing mask on a bright star and then remove the mask and slew to a dim star using the numerical data for fine focusing.



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Polar Alignment using a CCD Camera

For CCD imagers, the camera is the ideal tool for polar aligning the telescope. The ability to bin and then zoom in on the image or to obtain a sub-frame at full resolution, allows the misalignment motion of a star be detected and corrected without the strain of observing at high magnification with a reticle eyepiece. Follow the procedure below to make polar alignment easy and accurate.

1. Coarsely align to the celestial pole using two-star alignment or polar scope or by eyeball. Align well enough to ensure that your adjustments will allow polar alignment to be achieved. If you carefully level the base of your mount before beginning the drift alignment, you should only need to make one adjustment on azimuth and one on altitude. If the base of the mount is not perfectly level, then the two adjustments can slightly affect each other, requiring several iterations on each to achieve good polar alignment.
2. Aim at the intersection of celestial equator and the meridian. This is the point at which an error in azimuth alignment causes the maximum apparent drift in declination.
3. Adjust the camera rotation so that slewing the scope E/W causes no N/S change in the star's position. Move the scope's position if necessary to put a star near the bottom of the frame to make it easy to detect N/S motion as you slew the star E/W.
4. Pick star nearest the intersection that can be seen clearly in a 2-3 second exposure. Bin 2x2 or 3x3 if necessary to get reasonably fast update rates. A new exposure every 2-5 seconds is a good rate. Zoom in x3 or x4 to nearly fill the screen with the region around the star. This will make it much easier to observe small rates of drift. In CCDSoft, you may want to use focus mode because it continuously takes and displays new images.
5. In CCDSoft, open the histogram control, or for other programs any other small box that be moved around the screen (you could open any program and shrink the window to a small size). Place the top edge of this box so that the bottom half of the star is covered. Your screen will look similar to Figure 1.

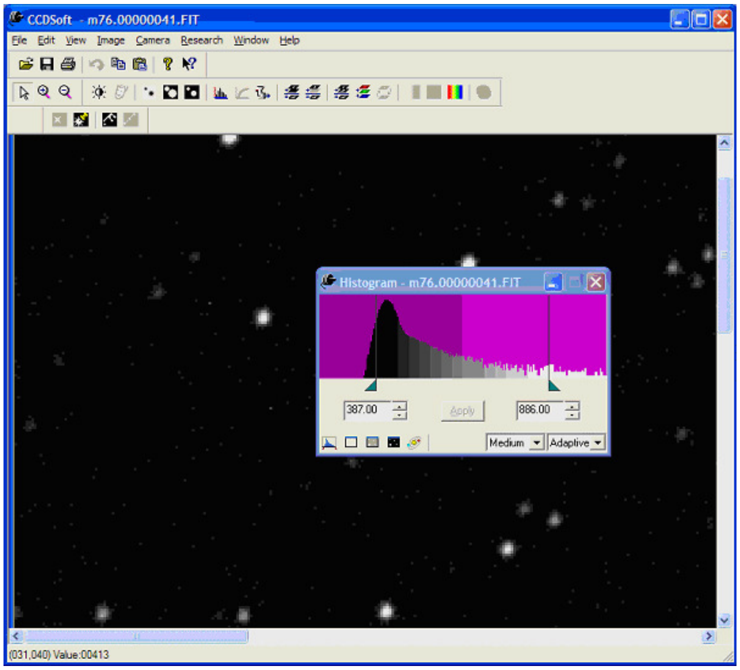

Figure 1: Cover half of star with a small box

1. Now watch the star to see if it drifts north or south. Adjust the AZIMUTH control on your mount or wedge as required to eliminate any N/S drift. After each adjustment, you may need to use a different star, depending on how much adjustment was made. For practice you can turn your azimuth adjustment two or three turns, say clockwise, and observe whether this causes the drift to get better or worse. By experimenting, you will quickly get a feel for how much adjustment is required to correct the observed speed and direction of drift. As you correct the drift rate, it will take longer and longer observations to determine the direction and speed of the drift. My rule of thumb is that if I observe no detectable drift in five minutes, then I am done with that axis.
2. For super-fine tuning, turn binning off, take a full frame exposure, select a small window with a medium bright star, and take images in focus mode. Repeat 4-6 in full resolution mode until satisfied with the drift rate. Very low drift rates can be easily observed and corrected in real-time.
3. Rotate the scope East or West along the celestial equator to a point 20 or so degrees above the horizon. Get as close to the horizon as possible. Seeing will limit how close you can get and obtain reasonably steady stars for alignment.
4. Repeat the same procedure but now only adjust the altitude adjustment on your mount until you observe no N/S movement of the star.
5. Return to the meridian and verify that the azimuth setting does not need further adjustment or adjust as required.

Once you gain experience with the adjustments on your mount, you should be able to obtain very good polar alignment in 30 minutes or less.

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Zeroing it in. Using a DSLR or CCD to Align Your Scope

By Robert Vice

For many years I have spent time learning the Star drift method of alignment for my telescope. Although tedious, it has turned out to be quite beneficial. However, after wasting night after night attempting to align the telescope properly, I have found an easier way of alignment.

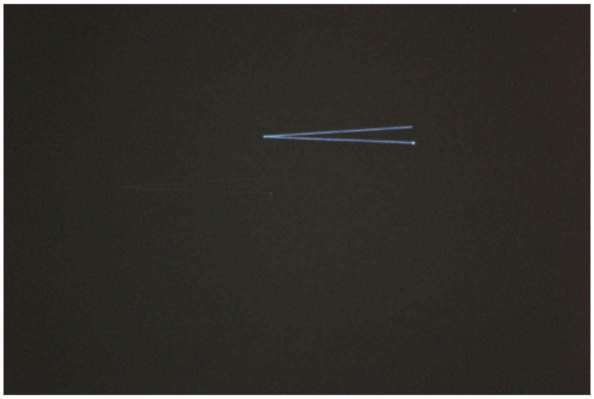
By modifying the photographic method of alignment to incorporate the newer technology such as a CCD cameras or DSLR camera, one can achieve an accurate alignment in just a matter of minutes instead of hours or days.

1. Setup and align your telescope normally.
2. Set your telescope to point due south and at 0 degrees DEC.
3. Find a semi-bright star. A 6th magnitude star works perfectly, but a dimmer star can be used.
4. Insert your CCD or DSLR camera into the eyepiece holder or attach via the t-adapter.
5. Focus the star for the CCD or DSLR.
6. Once focused, move the star to the right hand side of the camera sensor.
7. Set your telescope to its lowest drive speed. Typically a guide rate mode.
8. Set your camera software to take an exposure of 125 seconds. The first 5 seconds is used to create a point of reference on the image.
9. As soon as the first five seconds have elapsed, then press the W on the telescope keypad to cause the star to move to the opposite side of the sensor.
10. For the first minute continue to move the telescope West. As soon as the first minute has elapsed,

immediately reverse the telescope direction.

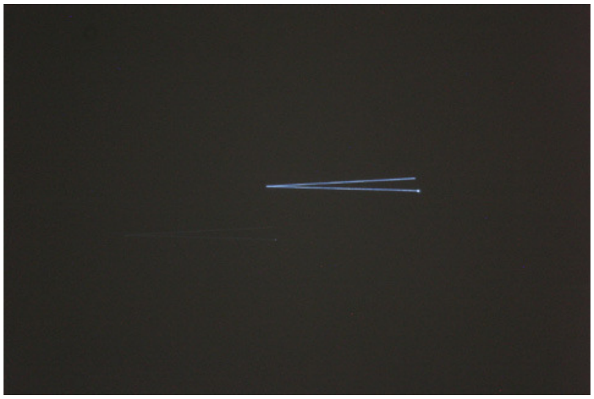
11. When the second minute has finished, stop moving the telescope.

12. After the image has downloaded, you should have something that looks similar to the image below.



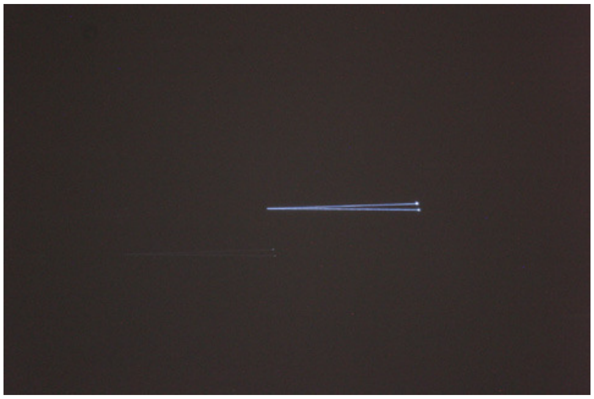
This is an initial image taken. What you see is the angle of deviation. What we are trying to do is to make the < a solid line. In order to correct this, we have to make some adjustments to the azimuth on the telescope mount. Notice that the initial star point is lower than where the exposure finished. This tells us that the telescope if pointing too far West. So to fix this, make a correction to the azimuth control to move the telescope East.
Now, follow the same steps again. When the image has downloaded, it should show that the angle of deviation has decreased.

Here we have the second image taken. Although both images look identical, the angle of deviation has decreased slightly. I need to make further corrections to the azimuth.

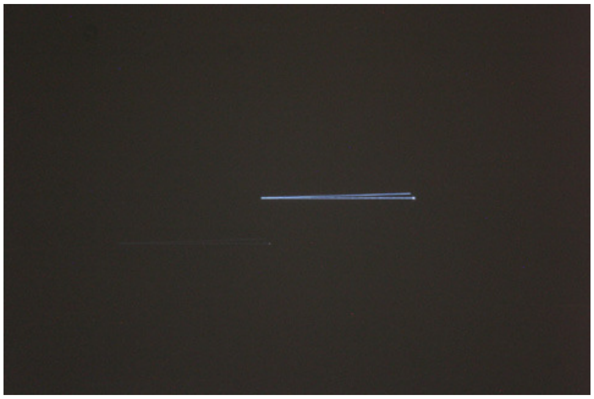


Here I have made another correction and the angle of deviation has decreased a little more. Still needs to be corrected again.

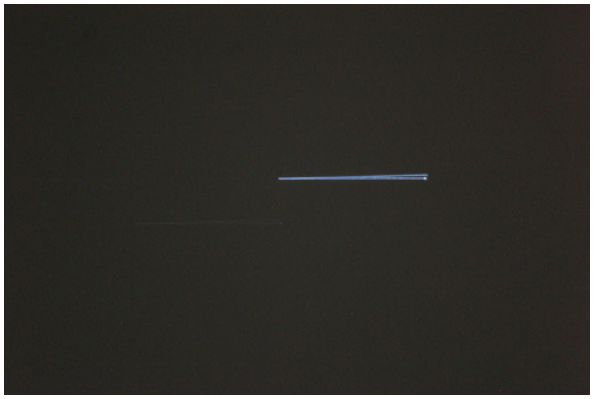
Here you can see the slight decrease in deviation over the last image. Still need to make further corrections



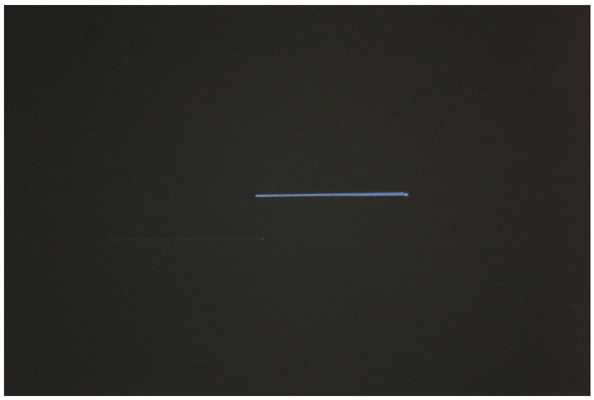
Now you can see that the angle of deviation has decreased even further. Will make further corrections to the azimuth.



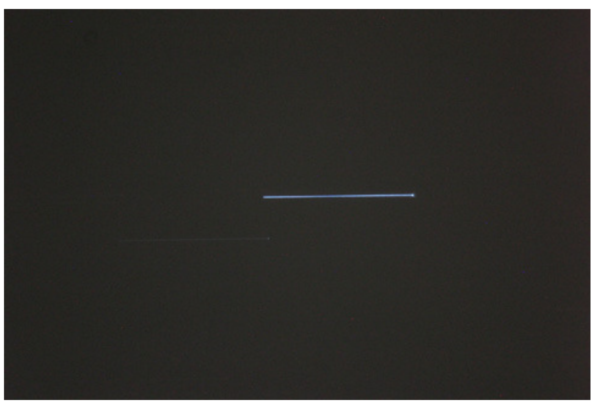
As we continue to make corrections, the angle of deviation has decreased greatly. However, we are still not finished. Continue to make a few more corrections to the azimuth.



Here you can see we have almost eliminated the angle of deviation. Make a few more corrections.



Here we are almost done, however, it is still slightly off. Will make another correction.



Here is a final correction. The star trail is a single solid line. The angle of deviation is now 0.
Once you have the azimuth fixed, you have to fix the altitude. To do this you simply move the telescope to a star along the Eastern or Western horizon and at 0 degrees Dec.
The only difference this time is that we adjust the altitude instead of the azimuth. The images will be identical when adjusting the altitude. However, you will have to adjust the altitude accordingly. Here you will either raise or lower the altitude until the star trail is a single solid line. If done correctly, you will have a very accurately aligned telescope.
Now that you are done with the altitude adjustment go back and double check your azimuth alignment. If everything checks out ok, then you are finished.
The images used are a two minute exposure done for demonstration purposes. You can increase the time exposures to increase the accuracy.
With the size of CMOS sensor and the FOV for my 8" f/6.3, you can see that I have a large area to play with. Two minute exposures only use a small area on my camera/telescope combination. If necessary I could increase the exposure times and go for about 10 minutes to cover the entire frame. That would create a much more accurate alignment than a two minute exposure.
So be daring and experiment with exposures to see how long you can go and how accurate you can make your system.
(Note: This method was used with a fork mounted telescope. Those who use a GEM must make different corrections, however this method will work with them as well and will increase their accuracy just the same.)

**Click on this link for this article in printable or downloadable .pdf format,
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Auto-Guiding with the SBIG ST-7e

It wasn't long before I got the itch to try to do longer exposures than 1 minute. This seemed to be a barrier that could not be broken for me without the aid auto-guiding. The inadequate wedge mostly caused this, but I didn't realize it at the time. So, I picked up a used SBIG ST-7e CCD Camera. This opened up another can of worms. The ST-7 is a lot heavier that the ST-237 and then attach the CWF-8a color filter wheel to it, that's around 4 or 5 lbs hanging off the back end of the telescope. That needed to be compensated for with a counter weight set. This is a mounting rail that attaches to the bottom of the OTA and a set of weights attaches to the rail. Their position can be adjusted to find the balance point in the deck axis with the camera attached.

Declination backlash also needs to be addressed. If backlash is not compensated for the auto-guider will be constantly overcompensating and will appear to oscillate with guide corrections. Backlash settings are found in the hand-controller.

Here is the excerpt from the Meade LX200 Manual for Dec Backlash Compensation.

1. Move to option #11 from the TELESCOPE menu. The Keypad display will show: BACKLASH 00." The "00" in the display shows the number of arc-seconds of backlash the LX200 is set to compensate for (the default setting is 0 arc-seconds).

2. While observing a star at high power, time the Declination movement delay when reversing the motor directions (by pressing the "N" and "S" keys). Typical values are 2 to 4 seconds.

3. The GUIDE speed for the Declination motor is 15 arc-seconds per second. Therefore, multiply the number of seconds delay by 15.

4. Press and hold the ENTER key for 1 second. The Keypad will beep and a blinking cursor will appear on the Keypad display. Enter the number determined in step 3, above. Press ENTER when the number is entered.

5. Check the time delay as described in Step 2, above. If there is still a time delay, then increase the compensation number. If there is a slight jump when reversing direction, then the number is too large.

My setting was 45 and was told from someone with more experience that that setting is a pretty good place to start with the LX200.

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Periodic Error Correction (PEC)

Once polar aligned, one would think that the LX200 telescope would track well enough for long exposures. After all, Meade did Name the thing LX, which stands for Long Exposure. Periodic Error has to be corrected for. Periodic Error is error is mostly within the worm gear but is also associated with the other surfaces in the drive train. Since the worm gear is not perfectly round, as it rotates, any error in its surface and shape causes a periodic bump in tracking. The period of this error takes one revolution of gear, which is 8 minutes for the Meade LX200. The Meade LX200 makes it possible to suppress this error by means of electronics - Periodic Error Correction (PEC), which Meade calls Smart Drive. The principle of PEC is based on recording tracking corrections made by observer by star tracking during one period. These tracking corrections are then applied during normal use.

Usually, PEC training is done manually by watching a star in a reticle eyepiece and making corrections with the hand box to keep the star centered in the reticle cross hairs. That can be such a pain in the back to be bent over an eyepiece for eight minutes and you're bound to get confused and enter the wrong direction key at least a couple of times. There is a simpler and more accurate way to train PEC. Use the camera's auto-guiding capabilities to do it for you. This assumes that you already know how to calibrate and use the auto-guiding feature of the SBIG ST dual chip cameras.

Start by pointing the Telescope to the area of zero degrees Declination and near the Celestial Equator. Find a suitable "guide star" at around .3 second exposures. Begin auto-guiding and wait for the corrections to get to there lowest point. If you did not select "auto" to select the guide star, it may take a few moments for the guider to send correction to the mount to get the star centered in the sub frame. Then navigate within the hand box: MODE, TELESCOPE, SMART and then LEARN. The hand box will read out where it is in the worm cycle starting at 240 and count down to start recording corrections being made by the auto-guider.

After the training is done recording the corrections, the drive corrections will be played back automatically, dramatically improving the R.A. drive tracking characteristics. This process should be repeated a couple of times, but on subsequent runs of PEC training (Smart Drive), be sure to select UPDATE instead of LEARN. This will update the corrections that have already been recorded. If your LX200 is having a trouble with the star drifting north or south, follow the same process, but select DEC, LEARN or UPDATE. My LX200 is permanently mounted in an observatory, so one would think that after going through the process that there would be no need for further PEC training. I perform a training session every time I use the telescope to allow for the different seeing conditions.

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