Autoguiding with the Meade DSI & Envisage Software

Foreword:

The goal of this document is to give users of the Meade DSI cameras and Meade telescopes enough information to successfully set up & use the DSI to guide their Meade telescopes. The author's personal experience is limited to the LX200GPS telescope with the Orion ED-80 as guide scope. Although users of other mounts and cameras should find this document useful, the reader may need to make appropriate allowances for the specific model or brand of equipment they use.

Why guide?

The main benefit of autoguiding is to compensate for residual periodic error in the telescope drive system. Periodic error results in trailed, or egg-shaped stars which detract from the appearance of our finished astro images. While steps can be taken in post-processing to reduce or in certain cases virtually eliminate these artifacts, generally the result is not as good as when the errors are eliminated in the beginning. Another benefit of guiding is that it can correct for minor alignment errors and tracking rate errors.

A secondary benefit of guiding is the use of longer exposure lengths, subject to the limit of our local skyglow or brightness of the object being imaged and the full-well depth of our CCD camera. The net effect is that we can optimize the image signal-to-noise ratio by reducing the number of times we have to read the chip, resulting in smoother final images that can potentially "go deeper" and record more faint detail.

***Autoguiding is not a replacement for proper setup, training, and alignment of your scope*!** Before undertaking to set up your guider, you must first optimize your mount & scope to deliver the best quality tracking it is capable of in unguided operation.

Where do I start?

1. **Examine your drive train and correct any mechanical issues** such as misaligned drive gears, excessive play in the worm/worm gear interface, etc. Do this before you do anything else, as changes to the mechanical systems will necessitate re-doing everything that follows.
2. **Train your drives**. It is recommended that training be done in alt-az mode as this reportedly provides more results than training done in polar mode. (If your scope is polar mounted on a wedge, you need not take it down to do this. Just "lie" to the mount by changing the setting in Autostar from polar to alt-az, and proceed. All that is required is that you have a view of a suitable stationary object.)
3. **Adjust your backlash settings**. If backlash is under-corrected, it may take multiple guide commands before the mount begins to move the OTA in the desired direction. this delay can result in trailing of the star shapes. Equally as bad is over-correction of backlash. When this condition exists, the mount "over reacts" to the guide commands resulting in a "jerky" motion. At best, this can result in trailing…at worst, the jittery response can cause the guide software to lose its lock on the guide star, and the mount will wander off unpredictably in search of the lost star.
4. **Balance your scope correctly**. For those using heavy guide scope mounted piggy back on the main OTA, this will probably require a 3-D balance kit. For best results, balance the scope such that it is slightly east-heavy, and slightly nose- or tail-heavy. The idea is to give the drive train a constant load to work against. If the scope is "perfectly" balanced so as to have no bias east or west, up or down, the OTA can oscillate slightly as the drives overcome stiction & backlash.

5. **Align your scope accurately**. Although the guider can correct for minor alignment errors, we want to keep these to a minimum. This will also improve the accuracy of your GOTOs, which is very helpful when trying to land faint targets on small CCD chips. If working in alt-az, make sure the scope is level. If working in polar mode, invest a few minutes refining your alignment using the iterative or drift alignment methods. (Note that in polar mode, some imagers will deliberately misalign their mount slightly so as to induce a slight, continuous error in the N/S direction. In certain cases, this can have a benefit similar to that of deliberately unbalancing the scope in one direction by causing the guider to issue corrections in a single direction).
6. **Train your PEC (if available)**. The idea is to correct as much of the periodic error up-front as possible, reducing the movements required of the autoguider to the least amount possible.

Now, your mount should be performing at its full "stock" potential. If you are lucky and are working at shorter focal lengths, you might not even need to autoguide. Most of us are not that lucky…our mounts still need a little extra help...

Choosing a guide system

The basic choices are to use a second, dedicated guide scope, or an off-axis guider (OAG). The advantage to an OAG is that it "sees" through the same scope as the imaging camera, thus pretty much eliminating the problems of flexure and differing focal lengths. The downside is the choice of guide stars is more limited, and the pick-off mirror can create a shadow area on the imaging CCD. As the author has no experience with OAGs, nothing further will be said about them, although much of what follows will apply.

The main considerations in choosing a guidescope are focal length, weight, and usefulness as a secondary imaging scope:

In general, a longer focal length guide scope is better, at least in terms of guiding accuracy. In years past, the recommendation was to use a guide scope with a focal length which was double that of the main imaging scope. With the advent of today's more advanced equipment and software which allows for sub-pixel guiding, the general wisdom seems to be that we can now reverse that ratio. (i.e., we can guide successfully with a focal length as short as half that of the imaging scope). Nevertheless, there is a limit, and conditions play a role. The longer the guide scope in relation to the imaging scope, the better and more accurately it will handle sub-optimal conditions such as wind, poor seeing, or imperfections in the mount.

The optical quality of the guidescope is not a critical factor – achromats and inexpensive department store refractors and even telephoto camera lenses can fulfill the role of guide scope admirably. However, for those of us who own long native focal length SCT's, selecting a quality APO or semi-APO scope as a guider gives us the additional option of reversing roles and using the guide scope as a wide-field primary imaging scope, while the "main" SCT acts the guide scope.

Next we need a method of rigidly mounting the guide scope such that it is aligned with the imaging OTA. Although alignment need not be perfect, it should be reasonably close. The bigger issue is flexure. The guide software will act to keep the guide star positioned on the chip of the guiding camera, which is "looking" through the guide scope. If the alignment relationship between the guide scope & the imaging scope changes as the mount tracks across the sky, the target will move across the imaging chip in direct proportion to the flexure between the two systems.

Connecting the hardware

We will assume for illustration purposes that the reader uses two Meade DSI cameras, one for imaging and the other for guiding. Certainly a wide combination of imaging and guiding cameras and software applications will work. As long as you are using a DSI camera and Envisage software for the guiding system, most of what follows should be relevant and easily adapted for your particular circumstance.

Both cameras are connected to the computer via USB. Note that the cameras are power-hungry. Use of a powered hub at the telescope is recommended. The guide camera goes in the guide scope, the imaging camera in the imaging scope. The cameras are plugged into the hub, or directly into the computer as appropriate for your system.

The orientation of the guide camera does not really matter, although the more "square" you can keep it with respect to the N/S/E/W motion of the mount, the better. The calibration step will identify the result of a given move command issued by the guiding software, and will automatically compensate for reversed or mirrored images, angular displacement, and the like. *(NOTE: in certain configurations with certain firmware releases, the user may need to reverse the control buttons on the Autostar handset in order to make the system work properly)*

It is permissible to use diagonals, reducers, barlows, etc to achieve focus and to manage the focal length relationship between the guide scope and the imaging scope. Note that every accessory adds an opportunity for flexure – make sure all connections between the guide camera and the guide scope are as secure as possible to prevent unwanted rotation or flexure of the guide camera with respect to the rest of the system.

The computer is connected to the scope via the serial port to the appropriate connection for the scope. On LX200 models, this is the RS232 port on the front of the scope, for 497 models, connect to the free port on the handset. Envisage only communicates via serial – do not connect to the guide port on LX series scopes.

Configuring the software

Upon launching the Envisage software, both cameras should appear, each with its own "live" tab. Take care to identify which is the guide camera and which is the imaging camera.

Enter the "FL in mm" value. (on the "Telescope" tab) This value is the net effective focal length of the guide scope, accounting for any focal reducers, barlows, etc. that may be in use.

Select the "Imager" you wish to guide with from the drop-down box. (on the "Telescope" tab)

"Connect" Envisage to the scope. (on the "Telescope" tab) It does not matter if you use the direct COM method or the Remote Server method.

The status box (bottom of the telescope tab) will change from "Scope NOT connected" to "Scope CONNECTED – can Autoguide" (or, depending on your scope & mounting mode, "Can Track"). The "Guide here" or "Track here" button which was previously grayed out will now light up, along with the "Will Cal" button.

NOTE: It does not matter whether the status message & Track/Guide button says "Track" or "Guide". "Guide" means your scope uses the GPS command set. "Track" means your scope uses the Classic command set. Both work equally well.

Compose the image – If you haven't already done so, now switch over to the main imaging camera's tab & position the target as desired in the preview window for that imager (not the guider window). Make sure the target is where you want it on the chip…the guider is going to keep it there for the rest of the session.

Set the guide exposure. Switch back to the guide camera's preview window, and set the live exposure length to a suitable value…one second is a reasonable place to start. Adjust the image controls as necessary to display the guide star clearly.

Select a suitable guide star. Switch back to the guide camera's preview window, and choose a brighter star with enough room around it to draw a tracking box about the size of your fingernail such that no other stars fall inside the box or are likely to "confuse" the software. At this point you will get the standard red tracking box with yellow crosshair. Make sure the software has locked firmly onto the guide star – adjust exposure time, focus, contrast, etc. as needed.

Click the "Track Here" (or "Guide Here") button. The software will now automatically go through a calibration routine. It will first issue an RA move, then a Dec move which will cause the guide star to move 10 or 15 pixels in each axis. There will be a series of movements which happen one frame at a time, so use a brighter star and a fairly short (1 sec or less) exposure time. As it does this, you will see various messages appear in the "Status" area at the bottom of the telescope tab.

When it's done, the "Will Cal" button will change to "No Cal" and a round yellow guiding reticule will appear where the guide star was located when you started the calibration. The software will now guide the mount so the guide star moves back to this position. The x and y deviation will display at the bottom of the "Status" area, updating as each new guide exposure is taken. You must wait for this entire process to complete, with the guide star back where it began, before you begin capturing images. This entire process could easily take 2 or 3 minutes, depending on your settings.

NOTE: If the guide star is driven AWAY from the guiding reticule at the end of calibration, you need to reverse the arrow keys of your Autostar hand controller for the corresponding (N/S or L/R) direction(s).

Fine-tune the guide settings. Once you have the guider running, observe the x & y deviation values at the bottom of the status tab. Your goal is to manage these values to be as low as possible…perfection would be 0 deviation in both axes (we never quite get there). A realistic target is to keep the deviation within +/- .5 – 1.0 pixels, realizing this is the deviation for the guide camera, not the imaging camera. If the imaging scope has an effective focal length 2x that of the guide scope, the error on the imaging camera will be the displayed value x2. Conversely, if the guide scope's EFL is 2x that of the imaging scope, the error on the imaging camera will be ½ of the displayed value.

Start your capture session. Let the guider run a minute or two to "settle in". Go to the imaging camera tab, set your image process, file type, save process, etc. Take your preview exposure & adjust the histogram, shadow enhance, etc. When you have verything like you want it, draw a tracking box around a suitable star for stacking alignment (*Note: it's easy to forget to do this!*) and click "Start"

Software controls

Exposure time – I usually find a guide camera exposure time of .77 seconds works well. If the seeing is good, you can set this lower (down to perhaps al low as .25 seconds). If the seeing is poor, the guider may have a tendency to "chase the seeing". Using a slower exposure time (1 second, up to perhaps 2 or 3 seconds) will help minimize this.

Correction Gain (corr gain) – determines the aggressiveness with which guide corrections are performed. Start out at the default of .50, and adjust up or down as needed depending on setup and conditions. A higher value results in a stronger correction, a lower value a more gentle correction. If the guider is not keeping up with the periodic error, increase the value. If the mount is over-correcting, reduce the value. Generally, values between .35 and .65 work well for my system.

Guide Rate – If your telescope is so equipped, you may be able to gain further control by adjusting the "Guide Rate" in Autostar. (I leave mine set to the default rate of 66%)

What the other buttons do:

Will Cal/No Cal - If you want to force a new calibration during the same session (due to a change in setup, for instance), click the "No Cal" button & it will change to "Will Cal". Now, click the “Guiding/Tracking” button to stop guiding, then click it again to start a new guide session. The software will now recalibrate.

Guide Last/Track Last – Should you interrupt guiding for a time to change filters, take flats, etc. and then wish to resume guiding in the same place you left off, this button will do it. Click the “Guiding” button to stop guiding (button changes to “Guide Here”), but leave the camera connected & running. Do your thing, and now return the scope to the same target area. Position the original guide star anywhere on the screen, draw a tracking box around it, and click “Guide Last”. The guiding reticule will appear in the original location, and the scope will guide the star back to the same place as before. (Be sure to wait for the guide star to fully return to this position & the system to stabilize before re-starting your exposures with the main imager).

Set Target – use this button to reposition the guide star to a new location on the preview window. With the guider running, click “Set Target”. Now, use your mouse to point to the new location you wish the guide star to be in the frame, and click once. The yellow guiding reticule will appear where you clicked, and the software will guide the star to the new location.

Center Target – works like “Set Target” above, but automatically relocates the guiding reticule to the center of the preview window.

I hope you have found this document to be useful. Please send your suggestions, corrections, typos, etc. to: chuckr54@yahoo.com

Chuck Reese 3-25-2006

Resources

Periodic error & PEC explained:
http://www.californiastars.net/lx200gps/tips/tips_pec.html

3-D Scope Balance
http://www.mapug-astronomy.net/AstroDesigns/MAPUG/Balancing_Loading.htm

Polar alignment using the drift method
http://www.darkskyimages.com/gpolar.html

Iterative Polar Alignment Method
http://www.covingtoninnovations.com/astro/iterating.pdf

Kochab's Clock polar alignment method
by Dr. Clay Sherrod
http://www.weasner.com/etx/ref_guides/polar_align.html

"Seeing" explained: The Pickering Scale
http://uk.geocities.com/dpeach_78/pickering.htm

Remote Server setup - illustrated
by Stephen Hamilton
http://autostarsuite.net/forums/3250/ShowPost.aspx

Autoguiding Primer
Excellent overview by Jim McMillan
http://acp4.dc3.com/McMillanAutoguiding11-2005.pdf

StarMate LX200 Emulator
http://www.2fdesign.co.nz/astronomy/lx200.htm

Losmandy mounting kits & balance systems
http://www.losmandy.com/secondary.html