SBIG's New AO-L High Speed Guider for the STL Camera Series

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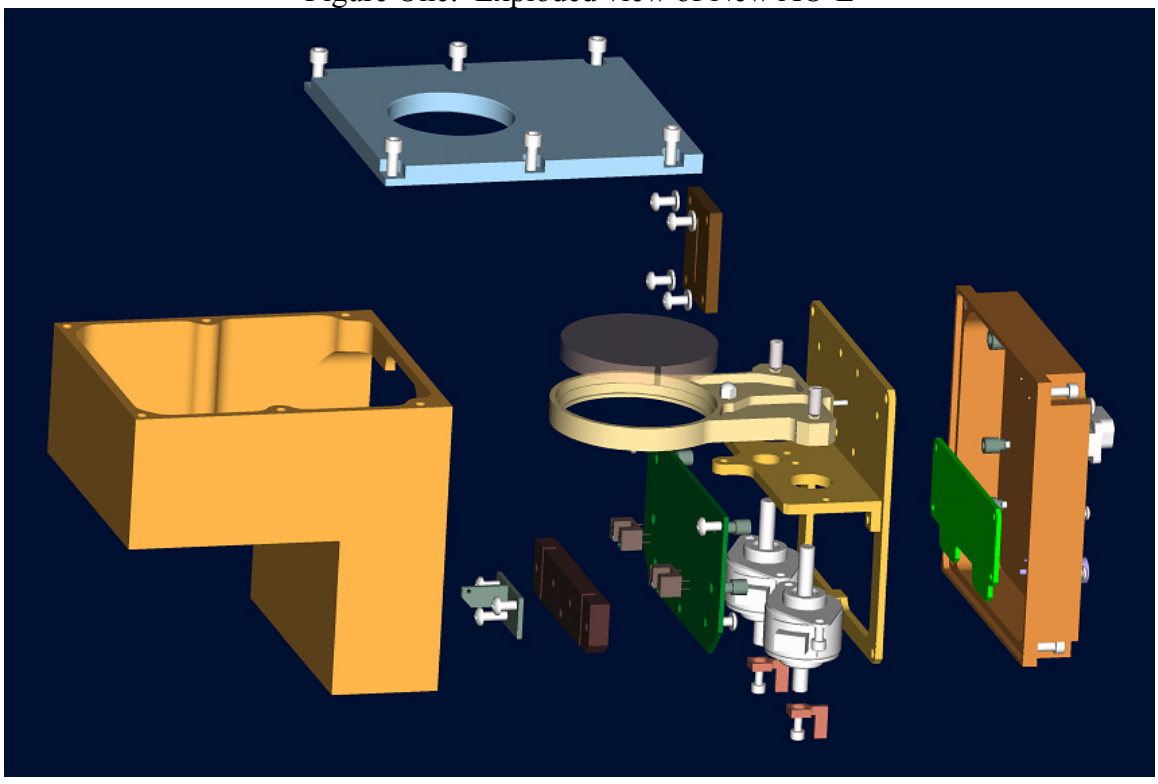
!!! Important Note: Remove the front cover and take the neoprene foam out of the unit before operation!!!

AO-L Operation:

SBIG's previous high speed guider, the AO-7, is unable to be used with the large CCDs of the STL cameras due to vignetting by the 50 mm diameter mirror it uses. At the 45 degree angle the mirror is used at it foreshortens to only 35 mm. It also had an issue with image rotation at large deflections which becomes serious for large CCDs, but is not a problem for the smaller CCDs of the ST series. For these reasons SBIG has designed a new Adaptive Optic device for high speed beam steering called the AO-L (Active Optic – Large Format). It does not have the range and speed of the old AO-7, but can cover the larger CCDs. It is shown in an exploded view below.

Figure One: Exploded view of New AO-L



The light passes through a 6 mm thick plane parallel plate that can be tilted by the action of two linear stepper motors in conjunction with a Delrin pivot point. The total amount of tilt in each direction is about +/- 4.6 degrees. The light beam is deviated by 36 microns per degree of tilt, so the maximum deviation is +/- 165 microns, or +/-18 pixels with an STL-6303. We have done careful raytracing to convince ourselves that no focal

shift or significant aberration occurs as the plate is tilted over these small angles, nor is there any distortion, rotation, or change in magnification. Our testing has verified these results. The window is AR coated with the same coating on our STL chamber window, and has less than 1% reflection per surface from 400 to 900 nm wavelength. Our assumption is that this device is being used with long focus telescopes where bright stars in the field of view are unlikely, and is not used with short focus refractors. Short refracters should not need a fast steering device like the AO-L.

The main advantage of the new technique is that it is thin, only using up 1.483 inches (38 mm) of back focus distance, whereas a mirror-based technique would probably require 6 inches (150 mm) of back focus. It is somewhat slower, since the motor can only tip the motor at 11.7 degrees per second, or 47 pixels per second. In this design moves are slew-rate limited. What this means to the user is that the user should use a focal length that does not produce too large of a star image. For example, if the seeing is bad and the star is 9 pixels across, it is probably jumping around by 4 pixels or so with each look, which would take 85 milliseconds to move. If under such conditions you reduced your focal length to where the star was only three pixels across, only 28 milliseconds are spent making the move, and you can achieve a higher update rate with the AO-L. The total overhead in the software for an AO-L move is 45 milliseconds. If, for example, you are taking 50 millisecond exposures with an optimized focal length (3 pixel Full Width Half Maximum stars), the total cycle time is 45 + 50 + 28 ms, or 123 ms (8 updates per second). The AO-7 advantage is that a move of any length is 20 milliseconds, but the exposure and overhead times were similar. Based on our experience and knowledge, AO-L and AO-7 rates help only slightly with reducing ground layer atmospheric turbulence, but are quite effective in reducing guide errors and wind buffeting.

AO-L Installation:

The AO-L is designed to be bolted directly to the nosepiece mounting plate on the front of your STL camera. The motor portion of the AO-L hangs over the top edge of the camera. The steps to attaching the AO-L are as follows:

1) **Very important**: Make sure the AO-L is unpowered so if a screw falls into it you do not get an electrical short.
2) Remove the top plate of the AO-L by removing the 6 screws that hold it down.
3) Remove the pieces of neoprene or foam that were inserted between the window paddle and the top plate during shipment. Save these in case the unit ever needs to be returned to SBIG. They cage the window paddle, keeping it from flying around when the shippers throw the boxes from truck to truck, and being damaged.
4) Using the 4 screws provided, attach the housing of the AO-L to the camera nosepiece mounting plate, which is 2.75 inches (7 cm) on a side. You can do this without removing the window paddle. Do this while the camera is unpowered. Be VERY careful not to let the screws fall into the camera. If they do fall in, shake them out carefully or remove the camera chamber front plate to reach them so as to not scratch the optical surfaces within the camera. You do not need to

remove the camera nosepiece front plate. If you do, be very careful to keep any shim washers found under it in the same position so as to maintain the squareness of the CCD to the optical axis.

5) Re-install the AO-L top plate. Attach your nosepiece to it.
6) Plug the cable from the AO-L into the I2C-AUX port on the STL. Download the latest drivers from SBIG and install them. At the time of this writing CCDOPS is the only image acquisition program that supports the AO-L but we expect CCDSOFT and Maxim will follow shortly.

Hints/Troubleshooting:

Stray light: There may be some concern about the gap above the AO-L window and the AO-L front plate aperture. At F/5 light passing through the gap will NOT hit the CCD, and there should be no stray light associated with it.

Cleaning: If the window ever needs cleaning it is much easier to clean it when the paddle assembly is out of the camera. If one removes the electronics cover on the AO-L the entire optical, mechanical and electrical assembly pulls out the side, and access is much easier. Use cotton swabs and isopropyl (rubbing) alcohol to clean the window if necessary. Cleaning is laborious – never re-use a cotton swab. Keep using fresh ones, and eventually all oil on the window will be removed. The AR coating on the window makes any residual oil very apparent.

Exercise mode: the AO-L should recenter every time it is powered up. You can also exercise the AO-L over its full range of operation using the AO exercise command in CCDOPS with 0.5 to 1 second per axis. The full range is about +/- 0.1 inch (2.5 mm) at the corners of the window. We have never had an assembly get lost and jam at the extremes of its range – contact SBIG should this happen.

Vibration: the AO-L does vibrate substantially in exercise mode, with an easily felt buzz. This is not a problem for the much shorter moves typical of actual operation, and when mounted to a substantial telescope.

Use with ST-Series cameras: SBIG will soon offer an adapter so the AO-L can be used with the ST- series cameras that have USB capability

Removal of Paddle: the paddle containing the window can easily be removed if necessary by unhooking one end of the spring and pulling it off the pivot point. The pivot point is a spherical ball with a snap fit.

Ghosts/Haloes: AO-L imaging here with a 12 inch F/8 Ritchey-Cretien telescope on the Beehive cluster, which contains many bright stars, revealed no trace of ghost reflections or haloes around the stars. They may be there at some low level, but we haven't seen them.