Menke Scientific, Ltd.
Barnesville, MD
www.menkescientific.com

C11 Upgrade

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Introduction

I have a C11 optical tube mounted on an Astro-Physics 1200 GTO mount. Although the optics of the C11 are quite good, I have been unable to obtain accurate pointing in the GOTO mode with inconsistent errors frequently in the 10-15 amin range. After investigation, I determined that the error was due to mirror *FLOP* in the C11, i.e., the mirror would move as the optical tube is aimed in different directions. I also concluded that the amount and direction of the error arising from the flops depended on the particular sequence of telescope moves, so it was virtually impossible to correct by software or similar means.

I noted that the mirror focus *SHIFT* (mirror movement during focusing) was quite small at about 1-2 a-min and is easily handled with RoboFocus. Mirror shift during focusing and mirror flop as the scope is moved are two very different issues.

This paper discusses the work I did to correct the mirror flop and the results I achieved. The work is easy to do, and takes only a few hours with no specialized tools or skills.

Initial Problem Identification and Fix

When I took the C11 apart, I examined the way the mirror was mounted on the moving cell. The mirror with its central hole fits around the center tube, and is attached in the rear to the cell with silicone caulk at the rear of the center hole. The annular space between the central tube and mirror hole is empty. There is a retaining ring on the central tube that is screwed down against the front of the mirror. Under the ring is a cork washer, and the ring is finger tight-not very tight. The function of the ring is clearly to prevent the mirror from falling off the cell if the silicone fails when the scope is aimed down.

The problem was clear: because the ring is not tight enough to prevent side to side movement of the mirror on the cell, there is little to prevent mirror movement when the scope is moved.

As a temporary fix, I inserted cork sheet tightly into the annular space, then screwed the retaining ring down tightly using a tool I made. After the repair, when I tried the scope the mirror flop was essentially nil (under 2 amin). However, the tight retaining ring had introduced obvious astigmatism showing that a tight ring is very undesirable. Never the less, I was able to use the scope in photometry for several months.

Rework

To improve the astigmatism and to reduce known internal reflections (especially from the moon within 25 deg.), I reopened the scope to change my method of correction. The corrector plate and tube are removed from the base; i.e., we do not remove the mirror, cell, focusing mechanism, etc.

Disassembly steps are as follows (presumably similar to the LX200)

- Put scope on clean, flat surface, braced to prevent rolling
- Use tape or indelible marker to mark the alignment of the base, tube, and front ring. Put an alignment mark on the corrector plate as it is corrected for one alignment only.
- Remove screws holding retaining ring that holds the corrector plate
- Holding corrector plate in place by using the secondary holder, remove the retaining ring (two people can do this more easily than one).

- Look carefully: You will see 3-4 small spacers (tabs) around its edge. Mark where these go around the circumference. Remove the corrector plate (it slides out with a loose fit). Put the correcting plate aside in a covered location. Save the tabs for reinsertion later.
- The mirror is now accessible. Make a paper or cardboard cover and, reaching into the tube, use masking tape to attach the cover over the mirror, with tape against the base of the scope holding it in place.
- You will now remove the tube from the base. The tube slides tightly into the base about ½ inch, and is held by screws/nuts around the circumference. Reach inside (don't touch the mirror) and you will feel nuts on the inside to match the screws on the outside of the base where the tube enters it. You may need to hold the nuts with needle-nose pliers while a second person unscrews the screws from the outside. Once the screws are off, you might put a tiny drop of oil on each one to make reassembly easier. There are about eight or so screws.
- Remove the tube and front ring assembly from the base of the scope. Mine was tight into the base, so I had to use a piece of wood and a mallet hitting on the front ring at the open end while an assistant held the base. After a few minutes of work the tube came out of the base with no problem.
- With the tube removed, the base, mirror, and central tube are exposed.
- Remove the paper mirror cover: you will see the retaining ring and its cork washer. Being careful not to touch the mirror (use plastic gloves), unscrew the retaining ring (mine was finger tight). Remove the ring and cork washer.

At this point you will see the annular space between the inner hole of the mirror and the central tube. Actually, what you see is the central tube of the mirror cell. As you change the focus, the cell moves in/out along the central tube. Because the mirror is attached to the cell in the rear only by a bead of silicone, the mirror can shift relative to the cell as the scope is shifted in direction. The object is to reduce this shift.

Some astronomers have evidently seen a large amount of slop between the cell central tube, and the main central tube: this would be an additional source of mirror flop. They reduced this slop using a variety of bearings and fixtures. However, measurements showed that our scope did not have this problem, but only the problem of the mirror shift in the cell relative to the central tube.

To reduce the shift, one could fill the annular space with a variety of materials. However, I wanted material that I could remove fairly easily at some later time—this rules out more silicone, epoxy, and similar materials. Rigid expanding foam would be good; however, I was not convinced I could get it into the small space. Also, I did not want to risk such sticky stuff getting on the mirror surface. I decided that rigid material would be best, thus ruling out rubber or similar stuff. Finally, I did not want to use wedges or other devices as they might well introduce astigmatism.

I chose to use fine, dry sand. With modest care, I poured sand into the space. After about 3/8 inch, I packed it using a Popsicle stick, then added more sand. When the sand got to just below the surface of the mirror, I used a hypodermic to put drops of thinned Elmers wood glue (2 parts water, 1 part Elmers) on the surface of the sand (to prevent loose grains). Obviously, during this whole process, you try to keep all stuff off the mirror, and you keep that mirror covered!

After the glue dried, I used a vacuum to clean the surfaces, including stray grains on the mirror (compressed air might scratch the mirror). Some sand grains had gotten into the retaining ring threads on the cell central tube. I used Q-tips to clean the threads: they must be totally clean or the threads will seize. I then replaced the cork ring and the retaining ring, tightening finger tight only.

After a final inspection, I put everything back together. Again, no problem.

Results

Before trying the scope, I readjusted the collimation (I just used centering the central spot when the image is out of focus). When I turned the scope onto stars, I found that there was no appreciable astigmatism. Further, when I went through the orthogonality procedure with the mount (I use the meridian offset method

described in the AP instruction manual), I found it easy to reduce the orthogonality error to below 2 a-min. I then went through the mount alignment process (again, using the methods in the manual). In performing these adjustments, I used my CCD camera as the detector. With about 1 a-sec per pixel resolution, measuring the exact error, and the exact effect of shims or other adjustments, was very easy.

The final results showed that pointing all over the sky was then within about 2 a-min. Because this pointing accuracy is fine for my applications, I have not tried to do better. There is no obvious sign of mirror flop.

Overall, the repair was quite easy, and was successful. While many people are reluctant to take apart their scopes, it is really not hard, and if you are reasonably careful, there is little risk to the scope. Give it a try!

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