Unattended Deep Sky Imaging

James (Jim) R. McMillan
valueware@msn.com
Original: December 3, 2004
Updated: October 7, 2005

This note is being written for anyone who:

1. Enjoys imaging deep sky objects (implies using multiple filters and requires autoguiding) and is not willing to compromise image quality for expediency.
2. Misses too many good imaging nights because of external conflicts.
3. Would like to image more often, but cannot afford to miss so much sleep – particularly on work nights.
4. Would like to make imaging less intrusive to the family during the evenings.
5. Would like to reduce the time commitment required for image acquisition.

As my personal interest in deep sky imaging grew, I found myself struggling with these issues. For me, the solution was to simplify and automate the process until I finally reached the point where my image acquisition is now accomplished totally unattended. During this process, I have learned much that might be of interest to anyone dealing with similar issues. This note is structured to provide some background and, while not a complete "how-to" tutorial, give specific advice about unattended imaging that may not be provided elsewhere. I also document the path I took getting to the point of achieving unattended imaging.

Please note that I am making a clear distinction between "unattended" and "remote" imaging. Unattended imaging implies 100% of a night's imaging run can be done unattended, but does not imply that physical access to the telescope is not available. In other words, tasks such as uncovering the equipment, powering up the components, etc. are physically accomplished by the imager.

Background:

Taking high quality ccd images takes a substantial amount of time. It is pretty routine for a single LRGB image to have a total of four or more hours of exposures. For those of us that are not blessed with dark skies, big scopes, and the most sensitive cameras, even more data must be gathered to try to offset our less than perfect conditions.

We also must contend with the fact that good imaging nights are often few and far between. The law of averages says 5 out 7 good imaging nights will occur during the workweek. If my imaging were limited to weekends when I could afford to lose sleep, it implied imaging only a few times per year. However, if I could image during the workweek as well, my imaging time could increase by a factor of almost four.

The result was embarking on a personal quest to put together a system that would allow me to image unattended. By that I mean, I would get the system set up and started, then it would do everything else while I went about my normal evening duties – including uninterrupted sleep. The object is to wake up in the morning with raw, high quality images of my desired targets, the scope parked, and waiting for me to put it away.

Happily, I can say I have achieved that goal using nothing but off-the-shelf hardware/software. Hopefully, this note will be helpful to anyone considering increasing their imaging time by creating an unattended setup.

Prerequisites:

There are significant prerequisites to unattended imaging. The simplest way to say it is that **all aspects of attended imaging must be mastered before even considering unattended imaging**. Once that is accomplished, there are some additional considerations that must be dealt with to be successful.

The key component to making unattended deep sky imaging possible is ACP (Astronomer's Control Panel – www.dc3.com). It glues all the necessary hardware/software components together and provides the means of controlling them for all the tasks required throughout a night's imaging. ACP also offers a broad range of functionality beyond that required for unattended deep sky imaging. While I am not affiliated with ACP in any way, I certainly am a proponent of its use because it meets my needs admirably.

Using ACP implies using specific control software:

1. MaxIm DL for imaging and camera control.
2. FocusMax for autofocusing with ASCOM driver for focuser control.
3. ASCOM driver for mount control.
4. PinPoint (now a standard part of ACP).

Automating Deep Sky Imaging Tasks:

Perhaps the best way to work through the issues is to list all the major tasks that must be accomplished automatically while imaging unattended:

1. Target(s) acquisition and centering.
2. Focusing.
3. Filter changing.
4. Guide star selection (including determining exposure length).
5. Guiding.
6. Image acquisition.
7. GEM flip (if required).
8. Calibration frame acquisition (dark, flat, bias).
9. Timing – e.g. when to start/stop imaging each target.
10. Park and/or shutdown when completed.

Handling all of these items is a standard part of ACP. I will not spend any time covering ACP setup and operations. ACP's documentation is already very good. However, one item, guiding, requires a special discussion with respect to creating an unattended imaging setup.

Guiding Considerations:

Unattended deep sky image acquisition requires always having an acceptable guide star available regardless of the target. Starting with ACP version 4.1.1 HotFix 6 (October, 2005), you now have a choice as to how you want to accomplish this: a) using an external guider with a relatively large FOV, or b) SBIG's internal guider with an instrument rotator.

Much has been written about this and the topic is sometimes hotly debated. The basic issues are outlined below.

External Guide Scope:

In a nutshell, **for external guiding to be successful, you absolutely need to eliminate all forms of "differential flexure" between imaging and guide cameras. ANY movement at all will smear the image – or at the very least, will reduce the image's resolution**.

With an external guider, the FOV must to large enough to insure a guide star is always available. That means a minimum of 15 arcmin x 15 arcmin; 1+ degree is best.

If your OTA has a movable mirror – such as an SCT – **you must completely eliminate any mirror flop**. Suffice it to say that Meade, in changing from their Classic to GPS design a few years ago, now incorporates a positive primary mirror lock and external focuser. Perhaps this provides clear direction for SCT owners dealing with mirror flop.

While it may be difficult tracing and eliminating all sources of differential flexure, it is quite easy to test. Just take a few guided images of typical exposure length (say 5 or 10 min.) in a sequence and blink-compare the results. If there is any problem, it will show up as images that shift by exactly the amount of differential flexure you have. You can be sure that any movement between images also means movement while the images are being taken as well, resulting in smeared images.

Internal Guider:

The SBIG internal guider is an extremely elegant solution for dealing with all forms of differential flexure. While it does nothing to eliminate it, it compensates for it by issuing guide corrections to compensate for any undesired movements. This works because the guider FOV and main imager FOV relationship are exactly the same regardless of any problems like mirror flop.

Those of us that have used SBIG's cameras with an internal guide chip know that it almost always requires altering the camera's orientation and/or changing the main camera's FOV to find an acceptable guide star. Fortunately, the market is beginning to supply rotators that can be software-controlled. However, there are still some considerations.

Since the guider FOV is small, perhaps only a few arcmin square, mount accuracy is important. ACP includes "re-centering" logic after each plate-solve, but that may not be sufficient to fully compensate for an inaccurate mount.

While a suitable guide star can be found for most imaging targets by adjusting the FOV and/or camera rotation angle, there may be a few where this cannot be achieved – at least not without an overly long guide exposure. This problem is exacerbated when using filters, particularly narrow band filters such as Ha.

The optical characteristics of your system probably change as the camera rotates. Therefore, it will require flats to be taken for each target/camera orientation. This also includes taking flats on both sides of the flip if you are using a GEM and image the same target on both sides of the meridian.

Taking images requires careful planning to pick the FOV and rotation angle that results in a suitable guide star being on the guide chip. This requires planetarium software that includes FOV indicators for main and guide chips (Starry Night Pro and/or TheSky). Fortunately, ACP now includes ACP Planner, a tool specifically designed to complete this task.

Which is best? My view is this: if you can **completely eliminate all forms of differential flexure**, external guiding is easiest with an unattended operation. However for many setups, this will be difficult, if not nearly impossible, to accomplish. In those cases, using an internal guider/rotator is the best solution. Happily, we now have that choice.

My Personal Progression To Unattended Deep Sky Imaging:

I thought it might be useful to track the progression of decisions I made over time with respect to my imaging over the last 6 years. I suspect there are many similarities to others.

1. Started imaging with LX200 10" F10 and 416XT w/201XT guider using 90 mm ETX as a guide scope. Purchased MaxIm for camera control/image processing because the Meade software was so bad. Added 6.3 and 3.3 focal reducers. Had lots of fun and got hooked on imaging, but image quality was not very good. There were many reasons for that, but mechanical issues were at least part of the problem. Further, setup/tear down time was significant.
2. Created a "permanent" setup; meaning I installed a permanent pier with electric/network connections in the back yard. The scope/camera stayed

permanently mounted on the pier and was covered with a tarp when not in use. Image setup time went from 45+ minutes to less than 10 minutes. A laptop at the scope was operated remotely from inside the house (via Radmin). Imaging no longer meant spending hours outside freezing! However, it still did require many, many trips outside to do various tasks (focusing, moving and framing new targets, guide star acquisition, camera rotation, etc.)

3. Replaced 416XT/201XT with used ST8E and AO7. Initially used conventional guiding with ST8E internal guide chip and achieved significantly better results (compensated for mirror flop issues), but found guiding was inconsistent. Learned to use AO7. Can honestly say that virtually 100% of my AO7-guided images had no guiding issues. The AO7 is absolutely wonderful in dealing with a less than perfect mount (LX200).
4. Added RoboFocus to main focus knob of LX200 and used FocusMax for automated focusing. This improved the consistency of my focusing and was a huge time saver. This began to open my eyes to the possibility of automating many aspects of imaging.
5. By this time, I was using MaxIm sequencing and an alarm clock for the typical imaging night. One of the biggest hassles was finding suitable guide stars – particularly when using filters. This was very labor-intensive. While I did try to do a lot of weekday imaging, I certainly paid a price in terms of sleep deprivation. It also took a lot of time throughout the evening, requiring semi-constant attention. That meant some good imaging nights had to be missed due to other commitments and/or that imaging competed with family time. Not good.
6. Decided that a separate guide scope would make life significantly easier, but I also knew the LX200 mount wasn't really up to the task. I bought an STV with eFinder and got on the list for an AP1200GTO. The new mount would be good enough for conventional guiding and create a long-term platform that would give me significant flexibility with respect to upgrading my OTA someday. In the meantime, I used the STV with the LX200. Generally, I took the Luminance exposures guiding with the AO7 and the RGB exposures guiding with the STV.
7. Received AP1200GTO after only 18 months (hit the timing just right, I guess). Installed LX200 OTA (sold fork mount). Conventional guiding with internal ST8E guide chip worked very well. Results were very similar to AO7 guiding in all but windy conditions. GEM flip very easy to deal with when using separate guider – a pain (meaning extra time required) when using the internal guide chip.
8. Began researching solutions for automating my imaging. The objective was unattended operations. Only one possibility – ACP. Bought it. It became apparent that an external guider was a requirement for unattended operations. (See #19. That's not necessarily true any longer.)
9. Began guiding exclusively with STV and eFinder. Three issues surfaced: a) the STV, while a great standalone guider, is not a very good computer-controlled guider, b) LX200 mirror flop was limiting the quality of my images, and c) ACP's guiding process (version 2.x), while ok, wasn't quite up to the task of fully unattended operations.

10. Sold STV and purchased used ST237a. Also bought used Orion 80mm Short Tube for the guider (better plate scale for my setup – 7.5 arcsec/pixel versus 15 arcsec/pixel with eFinder). My LX200 F10 focal length is 2575mm.
11. Developed a mirror flop solution that still allowed autofocusing via the main focus knob. Partially effective, but image quality was still affected (0.2 – 0.3 arcsec FWHM increase).
12. Began using ACP almost exclusively for my image acquisition. At this point, some interaction was required during the course of the night, but significantly less than before.
13. Worked extensively with Bob Denny (author of ACP) to improve ACP's guiding process. Bob didn't know me from Adam, but was very receptive to my suggestions. ACP 3.x was introduced (late Winter '04) and included everything that was necessary to support fully unattended guiding and also included a number of enhancements to improve other aspects of unattended operations.
14. By this point (Spring, '04), I could use ACP fully unattended for virtually all my image acquisition. That meant I could start it at 6 p.m. (it may not do anything for 4+ hours until it was dark) and it would run completely unattended from that point on. Often, I wasn't even home for the rest of the evening. It would image throughout the night while I slept and was ready for me to shutdown and cover the scope the next morning.
15. Wrote a paper about what I'd learned about conventional guiding throughout this process (http://acp4.dc3.com/McMillanAutoguiding02-2005.pdf)
16. Implemented my "final solution" with respect to LX200 mirror flop (11/04). In essence, I fixed the primary via setscrews accessible via holes drilled in the OTA and used an external focuser.
17. ACP v4 is in beta as I write this, but should be released within days. It adds even more conveniences for unattended operations. The items most important to me are improved pointing processes (I achieve less than 0.1 arcmin. error for any target) and the ability to automate taking all calibration frames – including flats. It also includes dome control and weather monitoring, making it possible to create fully remote operations.
18. Have made two suggestions to Bob Denny regarding a) auto-Plan generation (the process of telling ACP what to do for an imaging session), and b) adding the necessary functionality to use the SBIG internal guide chip – at least under certain conditions. (Of course, no promise that these will get added.)
19. I left #17 and #18 on purpose. I'm updating this on October 7, 2005. Version 4.1.1 HotFix #6 has been released. It includes numerous enhancements, but most importantly adds rotator support. I was Bob's beta-tester for this and am really impressed by how well it works and how "smart" it is dealing with all the details of making a rotator work with a minimum of user interaction. Bob also released ACP Planner a number of months ago, which automates Plan generation and includes specific rotator support.