Why Are My Gotos Off And What Can I Do About It?

Ken Hutchinson

July 30, 2010

Introduction

People who are new to telescopes, new to goto telescopes, or who are coming to Celestron goto telescopes from another brand will often struggle with getting good goto performance from their new Celestron goto telescope. Even old hands can sometimes have trouble with this. When I bought my second Celestron scope I was so excited about it that I neglected to apply the “Up/Right Rule” (more about this later) the first two nights I tried to operate it. Generally the scope worked well and I was happy with it but it simply could not “find” anything! It would barely put targets in the finder and they were nowhere near the eyepiece’s field of view. For targets too dim to see in the finder this made seeing them impossible, there was no way to direct them to the center of the finder field (which would put them in a low power eyepiece) if you cannot see them in the finder. The third night out I remembered the up/right rule, did my alignment procedure correctly and it was like magic. Everything I asked for was suddenly appearing in the center of the field, without fail!

There are two general kinds of Celestron goto telescopes. There are the fork mounted kind that can be operated in Altitude-Azimuth (or Alt-Az, or even AA) mode and there are the German Equatorial Mount (GEM) kind where one axis of the mount is pointed at the north or south pole, whichever is most easily visible from where you live. They generally operate the same since they all use Celestron’s NexStar Hand Controller (HC) and Motor Controller (MC). The HC is the part you hold in your hand, the MC is buried in the guts of the telescope or mount somewhere. Though they generally operate the same there are some differences which I will try to remember to note as I go along. Examples of the AA scopes are the CPC, NexStar SLT, and NexStar SE models. Examples of the GEM scopes are the Advanced Series GT (ASGT), CGEM, and CGE Pro telescopes. These are all available right now; if you are reading this a few years from now the models available could well have changed. AA telescopes can also be operated in equatorial mode by using a “wedge” to point them at the pole. This is an advanced topic I am not going to discuss. The internet group where you found this document will have plenty of people who can help you with that when you get to that point, if you get to that point. It is something you would only do if you plan to image, in most cases.

Things That Don’t Matter Nearly As Much As Some People Think

I will admit that this section will be held to be controversial by some. I mean no offense to anyone and if you want to obsess, as many do, about the items below you certainly do no harm. In my long experience with Celestron telescopes I have been and continue to be casual about all of them and observe no degradation in goto performance. If you feel otherwise let’s agree to disagree and get out there and enjoy the night sky!

The general setup of a goto telescope includes leveling the tripod and in the case of a GEM, aligning it to the pole. Leveling the tripod is good because it makes the telescope as stable as possible against tipping over. In the case of the GEM models if you need to adjust the polar alignment later on a level tripod can be helpful. Tripod leveling has virtually no effect on Celestron telescope goto performance though, so you do not have to be super careful about

leveling and you can in fact be pretty casual about it. Setting a Celestron GEM to the pole is also virtually a non-issue for goto performance. It has a huge impact on the tracking performance though. This makes it important for visual work because it eliminates the need to constantly re-center targets you are observing. It is also critical for imaging work but I am not going to discuss imaging here (I don't do that myself so my advice would be of limited value). By the time you decide to do imaging you probably will have acquired a mentor who can help you with that. The ASGT and CGEM models have a hollow polar axis. If you point the telescope to the east or west, and remove the covers on the polar axis you can look right through it. If you live in the northern hemisphere you can look through the polar axis, center Polaris in it, and you will be close enough to the pole for all but the most critical visual observer's taste. With a mount like the CGE Pro I power it up, tell it to go to its index position, and then I lay a green laser pointer along the dovetail rail and adjust the mount to point the laser at Polaris. I don't know any tricks in the southern hemisphere but you can ask your fellow local astronomers what they do and if any of them offer me suggestions I will include them in a later version of this document.

When you get to the point of starting an alignment you will be asked to enter your time/time zone, location, and date. This information is actually quite non-critical for goto performance. It will help greatly when the telescope slews to the first alignment star however. If the information is off the slew to the first star will be off, perhaps way, way off. So, generally you want to be reasonably accurate about the information you enter here. All the mounts I have used will remember your location from evening to evening so if you never move more than 100 – 200 miles from home with your scope you will never have to enter your location again. The same with the time zone information. You will be asked to enter your daylight savings time (also called summer time in some countries) status. That will have to be updated twice a year if you want to keep it current. On the lower priced models you will have to enter the time and date every night you use the scope, sorry. The mid priced models have a real time clock (RTC) that will remember that for you so you won't have to enter any of this information most nights with one of them. Some models have a GPS receiver built in that gives you the time, date, and location information automatically, very convenient but not necessary. If you want the convenience however many models can make use of the Celestron CN-16 GPS accessory. It may require the Auxiliary Port Module to connect to some models. Many models can also connect to a Celestron Sky Scout if you happen to have one. This requires a Sky Scout connect module but it lets the Sky Scout give the scope the GPS information. You can also use the Sky Scout to identify obscure stars you might want to use for alignment or calibration stars and you can use it as a "sky mouse" to send the scope to anything you see in the sky. So, there are many ways to get this basic information into your scope, choose the one that you prefer.

Oh, while time entry is something you can be casual about to ridiculous degrees and still get good general goto performance you do need a reasonably accurate time and date if you want to find planets and asteroids. You certainly need the right date and time accurate to a minute or two does not hurt even if it is not strictly necessary. Some things like satellite tracking (which requires a computer connection and external software) demand a time accurate to a few seconds for best results. And for observing the moon your location should be reasonably accurate too. Certainly if you are off by a few thousand miles the parallax of the moon can cause you to miss it in a goto slew. On the other hand even rank beginners generally have no trouble manually directing a scope to the big, bright moon!

General Alignment Comments

We have now come to the only part that is really critical to good goto performance. The next thing you will be asked to do is to center two alignment stars (though there are options to use one or even none) and if you are using a GEM up to four calibration stars. The HC will offer you

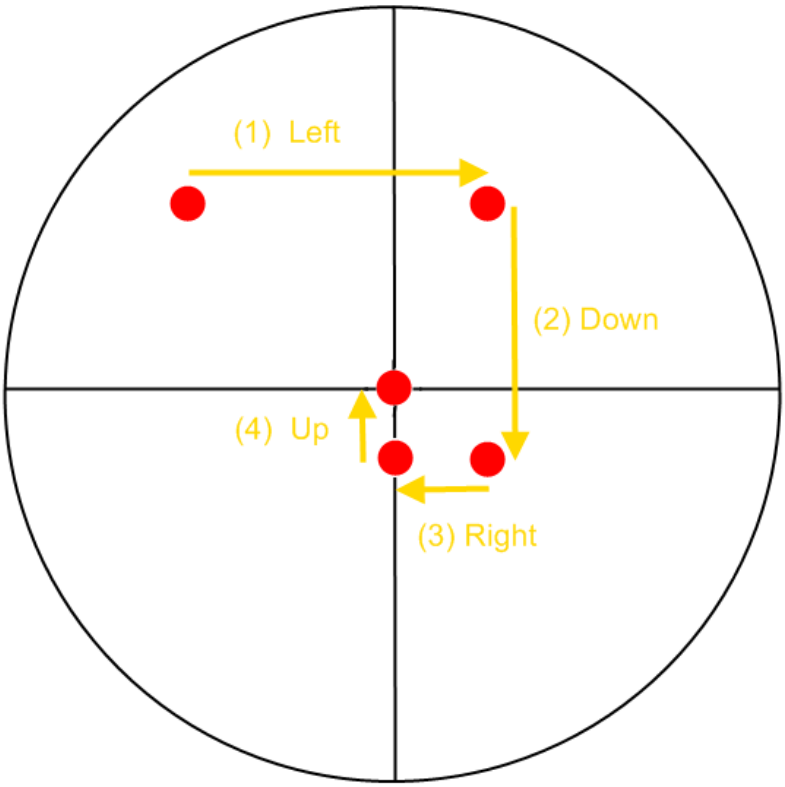
choices for all the stars, you can accept them or you can hit UNDO and scroll through the list to select different stars. If you are using an AA scope with Sky Align you just point the scope at three bright stars, one after the other, you don't have to know their names or choose them from a list. If you are using a GEM telescope you need to select your alignment stars from one half of the sky, east or west, and your calibration stars from the other half. The HC will guide you through this. In all cases the procedure will be to center the star in the finder first and the telescope will automatically select a high speed for the arrow keys to make this easy. Once you have centered the star in the finder you hit ENTER. The telescope will drop to a lower speed since the star will now be visible in your eyepiece (if you aligned your finder to your telescope as the owner's manual describes) and once you have centered the star in your eyepiece you hit ALIGN and the HC will then prompt you for the next star or tell you that it is done. On a GEM mount the mount will be tracking the sky as you do this which makes it easy. On the AA models the mount will not track the sky and you will have to position the star in the eyepiece field so that it will move through the center and then hit the ALIGN key as it does! If you played a lot of video games as a kid this will come naturally. It is easy enough to learn otherwise.

There are some tips you can use to get more accurate alignments. One is that you should use a reasonably high power eyepiece when doing the final centering of a star, that is when you are about to hit the ALIGN key you should be using a reasonably high power, about half the maximum your scope can use if you have an eyepiece in that range. Eyepieces with crosshairs or a reticule of some kind that marks the center of the field are also helpful. They are available from several suppliers; Celestron makes a nice one that may be more expensive than you care to spend if you are not going to make much use of its fancy reticule for anything other than centering alignment stars. If you don't have a reticule or crosshair eyepiece many folks find that defocusing the telescope so that the star is a round blob instead of a tiny pinpoint helps them to center it accurately. This trick can also be used with a reticule eyepiece since the defocused star makes it easier to see the reticule, easy enough so that I find I don't need to use the reticule illuminator. Keep this in mind if you use an illuminator, sooner or later its battery will be flat when you really need it and a defocused star might get you through!

The Secret Sauce

Virtually all reasonably priced telescopes and many expensive ones as well have a certain amount of "slop", technically called backlash, in the gears that drive the telescope. This slop is poison to goto accuracy and it must be dealt with to get good accuracy. If your Celestron telescope is not pointing accurately you are probably not doing the star centering procedure correctly. There are potentially many ways to compensate for backlash and other brands of telescopes use methods different from the one that Celestron has chosen. Celestron scopes deal with backlash by always approaching targets from the same direction. If you look through the eyepiece of a Celestron scope as it is doing the final slow approach to a target you can see which way the stars in the eyepiece are moving. When the scope stops press the arrow keys briefly to see which ones cause the stars to move in the same direction as the scope was just moving. In most cases this will be the UP and RIGHT arrow keys. Depending on the goto options you have changed in the HC menus and possibly your telescope model, firmware version, or hemisphere it could be different keys. **But the critical thing is that you must use the arrow keys that move the telescope in the same direction it moves when it makes its final slow approach to a target to center the alignment and calibration stars!** This is what experienced Celestron owners mean by the up/right rule. Generally it is the up and right arrow keys that you must use, but you can check your telescope to make sure by watching through the eyepiece as it finishes a slew as described above. If you find that a different key is required then change the instructions below as necessary.

At this point you want to ask me, “Now Ken, how can I possibly do this since sometimes I might have to move left or down to center a star?”, but of course you can’t since I’m not here in the room with you. So I will give you the answer in advance. When you do the initial centering of the star in the finder use any keys you need to center it. Now hit ENTER. If you need to use a low power eyepiece to center the star more accurately before using your high power eyepiece (and you shouldn’t if your finder is aligned accurately enough) you can again use any keys you need. When you pop in your high power eyepiece to do the final centering you can use the left or down keys if you have to but if so go too far left, go too far down, and then come back to center using the up and right keys. **Then and only then can you hit the ALIGN key to complete the alignment on that star!** This procedure is illustrated in the diagram below.



In the diagram the black circle and lines are the eyepiece field of view and the crosshairs (if your eyepiece has them). The red circles are the star you are trying to center. Let’s say when you start your final centering of a given star it is in the upper left quadrant of the eyepiece field as shown. Those of you with AA mounts are used to consistent operation of the arrow keys and might find the direction notations in the drawing above odd or even objectionable. Rest assured that we GEM owners are used to the fact that with different OTAs (Optical Tube Assemblies, that is to say, telescopes, which are easy to have on a GEM), different optical trains, and in different parts of the sky pressing an arrow key will produce anything except the expected result. So the above is possible for a GEM owner. So by pressing the LEFT key in the first step we note that the star moves to the right and closer to center. Because we are using the LEFT key we go past center and stop. Then we try the DOWN key and find it moves the star down and closer to center but we go past center. At this point we have the star positioned to move it up and right to get to the center. If you find that either the UP or RIGHT or both keys move the star closer to center when you first start this step then obviously you do not have to use the DOWN or LEFT keys at all. GEM owners have the luxury of moving the star directly to center and then

hitting the ALIGN key at their leisure. AA owners will instead have to position the star so that it will drift through center and then hit the ALIGN key just as it does.

My personal procedure is this once I get the star in the crosshair eyepiece. I immediately hit the LEFT key and stop if it moves away from center or continue past center if it moves towards center. Then I use the RIGHT key to bring it back almost to center in that direction. I repeat this same procedure using first the DOWN and then the UP keys. Now I am able to nudge the star with the short taps of the UP and RIGHT keys until it is right where I want it, in the center for a GEM or on course to pass through center with an AA telescope.

For GEM Owners Only

AA telescopes really only use two alignment stars. Even in those that have Sky Align one of the three stars is used only in a clever identification routine that can determine which three stars the user centered in the scope when the ALIGN key was hit. For best results with a GEM you need to add one or more calibration stars after the two alignment stars have been entered. The purpose of these stars is to help the firmware correct for some of the inevitable mount construction and operation errors. Things like cone error and flexure. The NexStar system is not a super sophisticated many star mount modeling system. On the other hand it is super sophisticated since it manages to accomplish much the same thing by clever use of a small number of calibration stars. The number of calibration stars you add is up to you (how accurate do you need to be?) and your mount (how much of the allowed manufacturing error does your mount happen to have?). For example, I have a CGE1400, the older version of the present CGE Pro. When I got it all it had was the older 2+1 alignment system, which is a shorthand notation that many of us use to denote the use of 2 alignment plus 1 calibration star. With the 50 pound C14 OTA that it came with and was purchased to make use of the pointing accuracy was awful. And I was not the only CGE1400 owner to have this problem. Yet the same mount pointed really well with telescopes up to 30 pounds. So something in the mount was flexing or otherwise having trouble when the weight got too high. The latest alignment firmware can be used with up to 4 calibration stars (a 2+4 alignment) and I found that my personal CGE1400 pointed **vastly** better with a 2+3 alignment. It is now a very accurate machine where before it was only marginally usable even with all my experience with operating Celestron telescopes properly. The AA mounted telescopes don't seem to need any of this to get good results and I have no idea why that is!

So, if you own a GEM plan on using at least 1 calibration star and up to 4 if you need them. When you go through an alignment you may find a fair amount of error in the slew to the first alignment star. Once you have that centered that the slew to the second alignment star should be a bit closer since the mount is partially aligned to the sky at that point. Your slew to the first calibration star will still be off because even though the sky alignment is done now and time and position errors are accounted for the mount errors are uncorrected. Once the first star is done the slew to the second calibration star should be pretty good. When that is done the third star should be quite good, or it is on my mounts. Some mounts may need 4 calibration stars and if yours does even the slew to the fourth star may have more error than you like. But once the fourth star has been aligned you should see good results on slews to your observing/imaging targets. As they say, your mileage may vary.

Now some mount errors, cone in particular, can vary slightly every time you remove and attach the same or a different OTA. Others should stay consistent or vary only slightly over long times as bearings, etc wear. So, you may find you do not need to run the calibration procedure every night, just the alignment procedure, depending on your circumstances, because the mount remembers the calibration coefficients it calculated the last time a full calibration was done. The

best case is a mount permanently mounted on a pier. When you are done for the night just Hibernate it using the HC menu function and turn the power off. Next night out you power it up, enter the time (on models that do not remember it) and you are good to go. No alignment, no calibration, no fuss! If your mount is mounted on a trolley or other scope transporting device and all you have to do each night is wheel it out the observing location without disassembling it each night then you will need to do the alignment stars each night but you should not need to do the calibration stars until you change or remove and replace your OTA. If you are a nomad like me and tear down the whole thing every night and reassemble it the next then you need to run the full process every night, sorry.

Closing Comments

This document is much longer than I expected. I covered a lot of things that people often ask about and worry over rather than just the “Secret Sauce” as I originally intended. There is one final tip that sometimes trips up beginners especially but even the seasoned hands on occasion. **You have to center the right stars when you are aligning and (for GEMs) calibrating!** Sounds simple but many of the star choices you are offered are obscure and it can be easy to make mistakes in some cases. One reason to be somewhat careful about the things I characterize above as relatively unimportant is that they will tend to produce more accurate slews to the first two stars. If you are reasonably close to the pole, reasonably level, reasonably accurate about time/date/location then your target star will almost always be the brightest one in the finder. Center that star in the finder, then the eyepiece and you should be right. But also take the time to use a paper sky chart or atlas or computer planetarium program or your Sky Scout to make sure that you have the right star if there is any doubt in your mind. Learning the sky is a fun part of amateur astronomy and can be used to impress your friends and neighbors. Sky Align users don’t have this problem, the telescope figures out on its own what stars were used for the alignment. You lazy people aren’t going to learn anything that way!

Celestron telescopes have proven to be remarkably accurate for me when I use them right. I hope this document will help you to use yours correctly. If you are reading it you likely already belong to at least one internet discussion group where you can get more help if you need it. If it is a general group you might also join a group devoted to your specific telescope or mount since they will have experience with the same equipment you use and know things about it that the rest of us only accidently find out about. You should also try to hook up with the nearest astronomy club. Most will have some members with experience with goto telescopes and that can be a huge asset if you are struggling with something that people can’t quite get you past with internet chatter or static documents like this one. You will also meet some great people and discover how much fun it can be to observe in a group.

Enjoy your telescope!