OCA Beginners Class

Session 6 - Astrophotography

Astrophotography

Taking photographs of objects in the sky

- Records the objects seen
- Records once in a lifetime celestial events
- Allows seeing dimmer objects that can not be seen with your eyes or your telescope
- See objects in color

Astrophotography can be performed with

- Only a tripod and a SLR or digital camera
- Telescope and a SLR, or digital camera
- Webcam, video or specialized digital camera can be used with a telescope
  - Personnel Computer may be required to see the objects, and to combine or process the images

Astrophotography

Types of pictures that can be taken

- Star Trails
- Asteroids, Meteors and comets
- Eclipses
- Transits - Planet transits across Sun
- Celestial objects (stars, planets, clusters, galaxies, nebula, etc.)
- Occultation's
- Sun spots
- Moon and craters
- Planet and Moon impacts
- Constellations

Getting Started

Astrophotography on a Tripod

- Moon and Planets at dawn or dusk: choose a nice foreground landscape (trees, mountains...). Evening just after the New Moon are very nice for that. Full Moon set above cities are very nice too. Use a 100-400ASA slide film.
- Constellations: Using a fast film (I like the Kodak Ektar 1000) and short exposures (30-45 seconds for a 50mm lens), one can record a lot of details on constellations. I got some nice results on the Milky way, especially around Sagittarius. Those pictures are also a perfect test for the photo shop: is the sky coming black from their lab?

Getting Started

Astrophotography on a Tripod

- Star trails: Long exposure will record star movement over the sky. Combined with a nice foreground, you can get some pretty nice results. Use a flash light or a Flash to show some trees or our telescope on the pictures. Use a 400ASA film for those pictures. For a very long rotation around the north pole use try a 100ASA film.
- Picture opportunities: bright comet, aurora, eclipses (lunar or solar), constellations, meteors...

Star Trails
Photography

Equipment Requirements (1 of 4)

- Astrophotography has special requirements for the type of camera used. Most astrophotographers use 35mm camera bodies and a few use larger format types.
- Capability to hold open the shutter for extended periods of time. This necessitates that the shutter control be of the manual type rather than the electronic or fully automatic variety. Most modern 35mm cameras manufactured today have electronic shutter controls. The small batteries in these cameras cannot withstand very long of holding open the shutter and will quickly deplete their charge and go dead. In this case, the shutter will close since there is nothing to physically hold open the shutter.

http://www.geocities.com/CapeCanaveral/Lab/6529/primer.html

Equipment Requirements (2 of 4)

- The best camera selection is one with a manual shutter control. With a remote shutter cable installed and the cameras shutter speed set to the "B" (or bulb) position, the shutter can be opened, and indefinitely held open, by depressing the button on the cable and locking it down with the thumbscrew on the remote cable.
- A second important feature to look for in a camera is mirror lockup. When the shutter button on a camera is depressed, two things happen in rapid succession. First, the mirror flips upward to allow the light entering the lens to get to the film and second, the shutter then opens. The motion of the mirror while retracting out of the way and the rapid sudden stop when it does, sets up a vibration in the camera and scope assembly that often will blur or create double images on the photo.

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Equipment Requirements (3 of 4)

- Purchasing a new camera that has manual shutter capability and mirror lock up these days is next to impossible unless one is willing to spend big bucks on some of the very high end models that offer manual as well as automatic operation. A better choice is to shop the pawn shops or used camera dealers for one of the older models that were made when manual control was the norm. There are several that are useful and a couple that come to mind were the Cannon F-1 body that was manufactured in the early 1970s and the Olympus OM-1.
- Lens: At this point, a short focal is recommended (35mm-50mm). More open is the lens, better it is (f-ratio around 1.5). Although some experts suggest using the next to lowest f-ratio setting.

Equipment Requirements (4 of 4)

- A cable-release: It allows to keep the camera open during the exposure. One can find it in any photo shop. Choose one that has an automatic lock system, it is easier than the one with a screw.
- A tripod: choose a light one, that you can take with you during your observing trip, hiking...
  - Can hang a heavy object (i.e., water bottle) down between the 3 legs to add stability.
- Front Cover: Use a piece of cardboard. Cover the telescope with it, then open the camera and wait for the vibration to stabilized, then remove the cover. Also can be use to prevent unexpected stray lights from ruining your exposure.

http://www.galaxyphoto.com/thizy.html

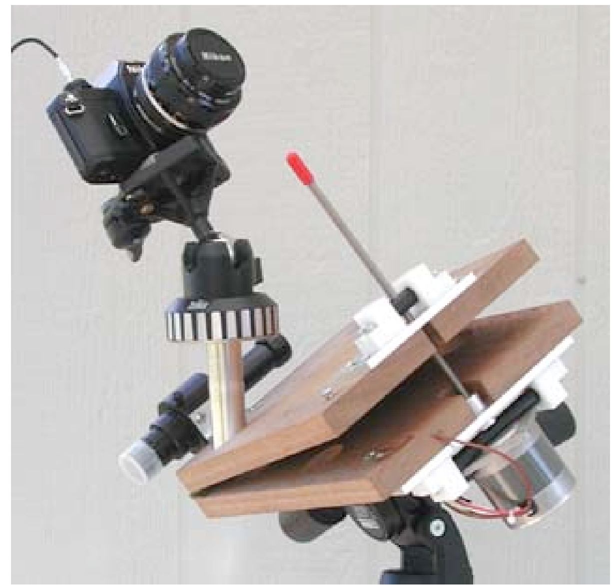
Astrophotography Tracking

- Tracking is essential to do long exposure on the sky and having round stars. With tracking, you can use slower film with less grain, or use longer focal to show more details on the sky.
  - Open loop Compensation for Earth rotation
    - Barn Door Tracker
    - Equatorial Telescope Mount
      - Piggy Back Photography
      - Prime Focus Photography
  - Closed loop Compensation for Earth rotation – CCD Auto-guiding

Barn Door Tracker

- A very simple way to track is to use two pieces of wood, a hinge, and a _ - 20 bolt. A quarter turn of the bolt every 15 seconds matches Earth rate. It is both cheap and fun to build, and you can have very nice results. Adding a rotating head between the barn door tracker and your camera will help orienting the camera to get the field of view you want. You may even add a one rev/min DC motor to make the tracking more automatic.
- Can allow exposures up to about 2 to 2 _ minutes

Barn Door Tracker



Piggyback Photography (1 of 3)

- You will need an equatorial mount for long exposures. An Alt-Azimuth mount will cause the image to rotate over time (field rotation).
- With short focal lengths (50-150mm), you won't need a very good polar alignment. If you want to do long exposure (1 hr for example) or use a long focal lens (200mm-500mm), you will certainly need a good polar alignment.

PiggyBack Photography

Piggyback Photography (2 of 3)

Type of objects for Piggyback photography

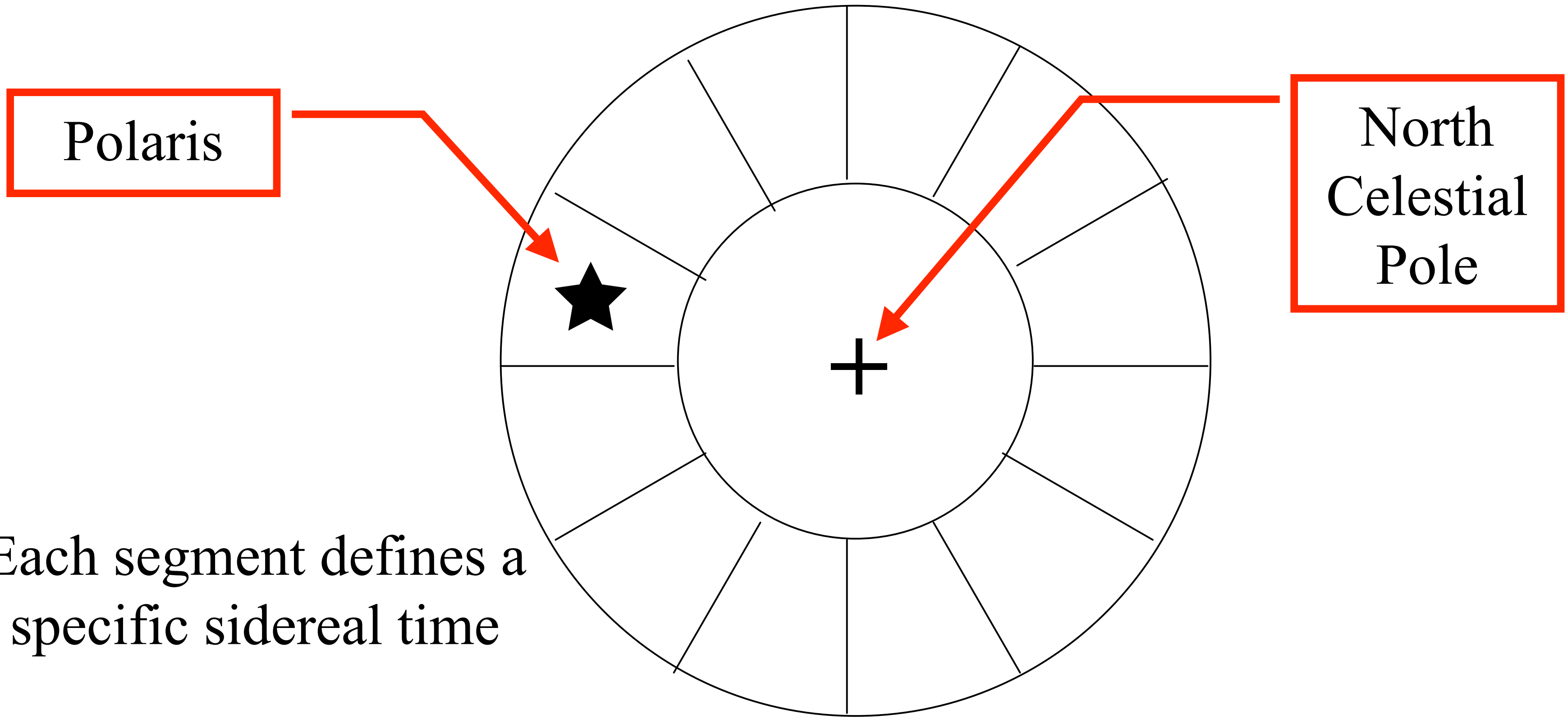
- Constellation: you will get much more details than exposures on tripod, and you can use finer grain films. And why not your own photographic atlas? Great as a finder chart later!
- Milky way: why not a mosaic of the milky way? In two hours, I did the milky way in August using a 50mm lens and Ektar 1000 film, 3 minutes each pictures. Great results!
- Comet or asteroids: bright one are easily accessible with a 50mm-150mm focal lens. 10-20 minutes with Ektar 1000 and a 135mm (F/2.4) gives nice results.
- Movement of planets over the sky: show how a planet retrogrades over a constellation.
- Shooting stars
- Solar / Lunar Eclipses

Piggy Back Astrophotography (3 of 3)

Methods for Polar Alignment

- Eye-ball with finder-scope or telescope
- Use a Polar alignment finder-scope
- Align using a mount with a polar alignment telescope
- Star Drift method
- And/or RA drive corrector with DEC motor

Polar Alignment Finderscope or Mount



Each segment defines a specific sidereal time

Paper dial computer is used to define which segment to put Polaris for every hour of every day

Star Drift Polar Alignment (1 of 2)

- The star drift method can be used to align your telescope to any accuracy. It takes approximately 30 minutes for a good alignment for a 500mm focal lens. First, level your tripod and orientate it to Polaris (not necessary, it just helps). If you have a Polar alignment circle, it can also help to use them.
- Look at a star near the Equator, South. Track the star in RA only, and look if the star goes up or down in your eyepiece (supposing your are looking straight at south with your head vertical). Rotate the azimuth of your telescope to adjust it until the star is not moving anymore.

Star Drift Polar Alignment (2 of 2)

- Then, move to a star at East (West works also). Do the same, but adjust the latitude this time (the angle between your telescope axe and the horizon plan). By switching several times from South to East (West), you should be able to adjust your polar alignment quite quickly. Of course, the first time you will spend a lot of time; take notes of what you are doing, and it will be much quicker the next time you do it.
- Continue star drift process until the star does not move for the time you want to take an exposure

Prime Focus Photography

Prime focus photography through a telescope provides a capability to record faint objects, show spiral arms in galaxies, or record the central star of a planetary nebula, or record a planet.

Equipment needs

- Telescope: Large aperture with fast optics is a plus to record faint objects. A good refractor is great for planets.
- Telescope should have a drive corrector to track on RA and allow correction. A DEC motor is also useful.
- PEC: Periodic Error Correction is a great invention. You spend some time (usually ten minutes) to setup the PEC, but guiding is much easier.
- Attachment to connect camera to telescope – T-Ring adapter

Prime Focus Photography

Prime Focus Photography

- Reducer/Corrector: A short f-ratio is nice for deep sky astrophotography, it allows shorter exposures. For SCT, there are reducer that also correct the field of view. It allows also to have a full image on the film.
- Off-Axis Guider: Guiding is critical to obtain nice round star on long exposures.
- Finding a guiding star is not always easy. Use a low power eyepiece to find the star, then switch to a higher power eyepiece.
- Front Cover: Use a piece of cardboard. Cover the telescope with it, then open the camera and wait for the vibration to stabilized, then remove the cover. Also can be use to prevent unexpected stray lights from ruining your exposure.

Prime Focus Photography

- Deep Sky filter: If you live in light polluted area, a Deep Sky filter can help you to limit the sky fog effect. It is an optional accessories; but after several pictures taken, it may become necessary.
- Polar alignment for prime focus is much more important than for piggy back.
- Focusing is also very important for prime focus astrophotography. Do not expect to do proper focus just by looking through the camera, it is not precise.
  - Aperture Mask
  - Focault
  - Image Magnifier

Precise Focusing – Aperture Mask

- The simplest and cheapest is a simple aperture mask over the front of the scope that has two holes cut 180 degrees apart. The size of these holes varies depending on the aperture of the scope you are using (about 2" diameter for an 8 inch aperture and maybe 3" for a 10"). Unless you have a computerized scope such as an LX 200 or Ultima 2000 with "Go To" capability, you must use the finder scope to make an accurate mental or hard copy map of the position of the scope while it is on the object to be photographed. You now move the scope to a bright star nearby and look through the camera viewfinder for the star. Most likely, you will see two stars with the same brightness.

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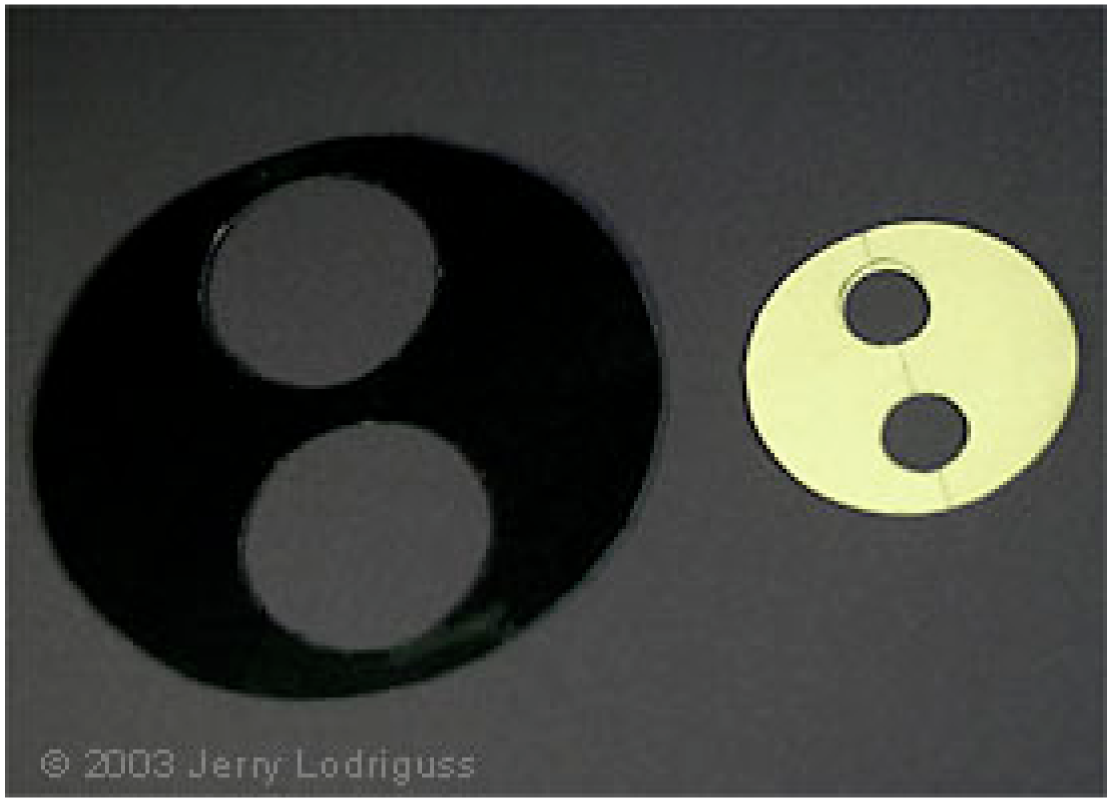
Precise Focusing – Aperture Mask

- Move the scope focus in or out and you will notice the stars will begin to converge or diverge. What you want is to converge them into a single stellar image as accurately as you can and after doing so, you are in focus. Now move the scope back to the photographic object and using the locator map you made previously, position the scope EXACTLY as it was before. You can now make the photograph.

Aperture Mask



Prime Focus Photography

Focault method - A razor edge to cut a star beam.

- Another method uses a device called a "knife edge focuser" to get a precise focus. This employs the fact that a well focused star makes a small pinpoint of light on the film plane of the camera. The knife edge focuser in simple terms is a very thin edge that when placed at the precise prime focus of the scope will cause a well focused star to quickly vanish from view when the scope is moved in a direction that will cause the knife edge to occult the star. An out of focus star will not quickly vanish but will appear to slowly dim out as it is occulted.

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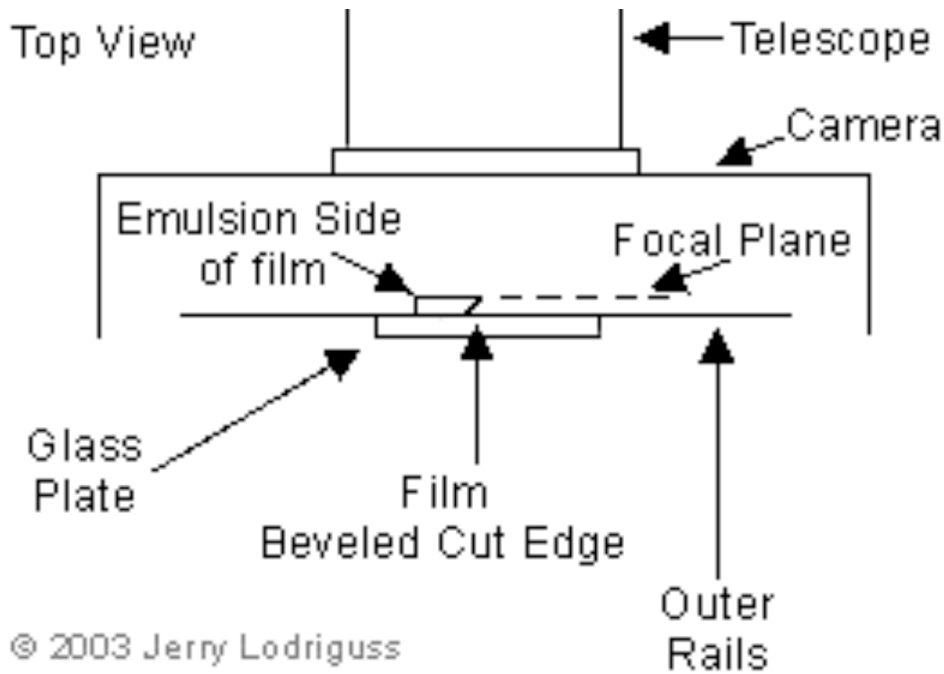
Hardware for Focault Method



Prime Focus Photography

- Point the telescope to a star, and do an approximate focusing through the camera. Then, open the camera body (without film!), and open the shutter in B exposure. You should see the star pattern, as a donut shape through a SCT telescope. Take a razor blade, and tape it on the camera, exactly where the film should be.
- By moving the telescope (can tape the razor blade in order to be able to cut the beam just by moving in DEC), the razor edge will cut the star beam. If the razor is out of focus, the star pattern will disappear slowly from one side or the other depending if your are inside or outside of focus. At the focus point, the star pattern disappears suddenly, and it is hard to tell from which side.
- This is an easy method, and it takes around 5-10 minutes to do it. It is very precise, and pictures will gain in sharpness.

Precise Focusing – Other Methods

- Another and perhaps better method is to change the focusing screen of the camera to one with less matting to make the views brighter. Some cameras will allow you to do this and some won't.
- Other methods are more costly. Remove the top cover of your camera and the viewfinder prism. Replace with a store bought or a homemade focusing magnifier directly on top of the focusing screen to get very precisely focused shots.

Camera Focusing Screens

Camera Viewfinder Magnifier

Camera Viewfinder Magnifiers

Guided Prime Focus Photography

- Ever wonder how the guys who get the photos published get such fantastic images? Most of them have their parlor tricks in the photo lab but all use one technique for making the photographs through the scope: their shots are guided either manually using a reticle eyepiece or the guiding is done automatically with a CCD autoguider.
- Guiding requires the scope drive to have the capability of being adjusted or "corrected" in right ascension to compensate for drive errors caused by either manufacturing inaccuracies in the drive components or variations in power voltage. In addition, the capability to correct in declination in addition to right ascension, is highly desirable.

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Guided Prime Focus Photography

- Other errors that have to be corrected for are caused by atmospheric scintillation and positional errors resulting from refractive effects of having to photograph through less or more of the atmosphere as the object moves toward or away from the horizon in the east or west as the photographic object "moves" with the earth's rotation.
- Two of the most popular and almost universally used techniques of guiding are
  - (1) the use of an off-axis guider.
  - (2) the use of a separate guiding scope
- Both methods use either a reticle eyepiece for visually monitoring the scope's tracking or they use a CCD autoguider to automatically do this in place of an eyepiece.

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Off Axis Guider

Off-axis Guider (1 of 3)

- An off-axis guider (OAG) employs the use of a "pick-off prism" that is located about midway in the projection tube part of the off-axis guider body. An eyepiece barrel is manufactured into the body of the OAG at a perpendicular angle to the axis of the scope and camera and this eyepiece barrel is situated precisely over the pick-off prism so that a small fraction of the light coming through the scope can be diverted into the eyepiece barrel. The pick off prism extends down into the light path just enough to intercept some of the off-axis light coming through the scope's optics (this is of little concern since most of this light would be wasted anyway since it is so far off-axis that it would never get to the film plane of the camera anyway).

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Off-axis Guider (2 of 3)

- A reticle eyepiece (one with a crosshair pattern or similar arrangement) is inserted into the eyepiece barrel of the OAG and is used to monitor the position of a "guidestar" and thus allow the user to make appropriate corrections to the scope drive if tracking errors are detected. The camera is attached to the off-axis guider body utilizing a T-ring in exactly the same manner as is done with the T-adapter.
- A suitable guide star is selected by first framing up and centering the object to be photographed. The reticle eyepiece is inserted at this time and is focused by sliding it in or out of the barrel until focus is achieved. It is then secured in focus with a thumbscrew.

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Off-axis Guider (3 of 3)

- If a suitable star is not located, a radial search must begin. With the simpler made versions of OAGs, this is done by loosening the threaded slip ring (secures the OAG to the rear cell of the scope) and radially moving the entire OAG-camera assembly while looking through the reticle eyepiece until a star is located. After doing so, the slip ring is securely tightened. Other (and more expensive) versions of OAGs provide the capability to make radial searches without having to loosen the slip ring and possibly screw up a nice composition in the camera. A single thumbscrew is loosened and the eyepiece barrel can be rotated independantly of the guider body and camera combination.

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Separate Guidescope (1 of 4)

- Use of a separate guidescope that is mounted on top of or alongside the imaging scope. Both scopes are driven on the same mounting and theoretically any variance seen in the tracking of one will also be seen by the other.
  - The major advantage is that the acquisition of a suitable guide star is much easier since the guidescope can be independently aimed (within limits) of the imaging scope
  - The second advantage is that the images of the guidestar will be far superior to those provided with an OAG. Most off-axis guiders are used with Schmidt Cassegrains (SCTs) that use spherical primary mirrors that, by nature of their figure, have a lot of spherical abberation and coma. Sadly, this is the very light that off-axis guiders have to work with and thus the images seen in the reticle eyepiece are not exactly "pretty".

http://www.geocities.com/CapeCanaveral/Lab/6529/primer.html


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Separate Guidescope (2 of 4)

- Major disadvantages of a separate guidescope are
  - Cost
  - Increased weight and less portable
  - Mount may have to be a larger to handled increased weight of separate guidescope
  - Requirement for a very sturdy attachment mounting that will keep the guidescope in perfect alignment with the imaging scope (Differential Flexure)

Differential Flexure

- When operating at focal lengths of 1500mm or more, even the tiniest bit of flexing from the weight of the guidescope in either the guidescope optical tube or in the mounting to the imaging scope will cause a loss of alignment of the two. Thus, as the main scope mount tracks the sky, slight changes in the center of gravity can cause the two scopes to get out of alignment with each other. The result will be "unexplained" trailing of the stars even though the photographer knew his or her efforts at guiding were near perfect.
- Differential flexure can and is avoided by experienced astrophotographers who use separate guidescopes. The remedy is good engineering of the mountings between the two scopes and a healthy investment of cash to either buy or custom manufacture suitable mountings.

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Separate Guidescope (3 of 4)

- The guidescope doesn't have to be of the same quality as the primary instrument but does need to have a primary focal length of at least half that of the main tube. Ideally, it should be equal to the imaging scope but in most cases this is not practical because of cost, weight and protability considerations. Smaller and lighter scopes will surfice since their focal lengths can be increased with the use of a barlow or other lens. A rule of thumb is that the operating focal length of the guidescope should surpass that of the imaging scope by a factor of at least two to three times.

Separate Guidescope (4 of 4)

- If you plan on using a CCD autoguider at some point in the future, be aware that autoguiders prefer nice pretty star images much as your eye does and the task of configuring the adjustable parameters of an autoguider is much tougher if the star images are smeared with spherical abberation and coma. I'm not saying that autoguiders cannot be used with OAGs but rather that the set-up times can sometimes be frustrating.

Eyepiece Projection (1 of 2)

- This is a technique used whenever high magnification shots are desired of the moon, planets, and nebulae and galaxies. Basically it involves the use of an eyepiece projection tube (commonly called tele-extender) that in many ways is similar to a T-adapter. With this device, however, an eyepiece can be inserted into the light path between the scope and camera to enlarge or magnify the images going to the camera.
- The attachment of the tele-extender to the scope is somewhat different than the T-adapter. With this technique, the visual back of the scope is used without the star diagonal. The eyepiece is inserted into the visual back and secured with the thumbscrew. The tele-extender is then threaded to the visual back and the camera body is attached to the tele-extender at the other end with a T-ring.

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Eyepiece Projection (2 of 2)

- This technique is also the most difficult to do successfully. Due to the extreme focal lengths used, very PRECISE tracking and polar alignment is called for. These extreme focal lengths enlarge on the film surface a fixed quantity of light coming from a relatively small object (or area of an extended object) and thus require exposure times to be relatively long. Use exposure lengths of 1/2 second to 4 seconds depending on the brightness of the object and the focal length of the eyepiece used. Exposures any longer will most likely result in blurred images due to scintillation or tracking inaccuracies.

Reticle Eyepieces (1 of 4)

- There are two basic types of reticle eyepieces and many variations of each. These are the standard reticle and illuminated reticle eyepieces. First of all, let's eliminate the first, since in my opinion their use is practically zero. Ever notice how hard it is to see the crosshairs in your finder scope at night? Nuff said about the non-illuminated type.
- Illuminated reticle eyepieces are absolutely necessary for guided astrophotography and a few features they may or may not have will now be addressed.
- Guide stars can be tough to find, see and track. One would think that with all the stars in the heavens, surely a star bright enough and well positioned for guiding purposes would be easy to find. But that is not always the case.

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Reticle Eyepieces (2 of 4)

- Important features
  - Capability to either dim or brighten the illumination of the reticle. When working with marginal guide stars, sometimes the reticle needs to be dimmed to near invisibility to keep from washing out or overpowering the guidestar. A too bright reticle can make the use of dim guidestars impossible.
  - Capability to "blink" or turn on and off the reticle automatically while the photo is being made. Monitoring accurately the position of a dim guidestar is made much easier if the eye is allowed to rest from the glow of the reticle for brief periods. This allows the eye to stay much more sensitive to low levels of light and thus allow much dimmer guidestars to be successfully used.

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Illuminated Reticles

Reticle Eyepieces (3 of 4)

Important features (continued)

– The selection of the reticle pattern is the third most important feature.

- Double reticle type that forms a small box at the intersection point of the reticle lines. This box provides an excellent guidance tolerance when making the photo. By keeping the guidestar within the confines of the box or as closely as possible to it, a well guided shot can be made.
- Angular separation grids are great for determining the position angle and separation distance between two closely spaced stars but for guiding purposes, they are next to worthless. Any superficial clutter in the reticle pattern only makes for more difficult guiding when using faint guidestars.

Reticle Eyepieces (4 of 4)

Important features (continued)

- Illuminated reticle eyepieces get their reticle illumination from a small light emitting diode (or “LED") built within or inserted into the side of the guiding eyepiece. the LED is powered either by it's own self contained battery or by the scope's power supply. The selection of either type is determined by the type of scope and its features or by personal preference. Both can work equally well.
- The selection of the optical type is really not important. Wide fields of view are unimportant unless the user has other special requirements of the eyepiece other than its use as a guiding eyepiece. The most important consideration, however, is that it be well made and of good quality. Prices range from about $50 for the most basic up to about $200 for the higher quality ones.

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Films for Astrophotography

- **Recommended Films for Deep-Sky Astrophotography as of July 2003** Here are a few good films to try based on results obtained in deep-sky images by different astrophotographers.
- Astrophotography is an art *and* a science and everybody's experiences will be slightly different. The best way to learn it is through trial and error. Remember, your mileage may vary - you *have* to test with your procedures and your setup and see if the results are acceptable for your purposes.
- These films are mostly rated as being good because of their sensitivity to the red hydrogen-alpha wavelength which is important for recording emission nebula. For continuous spectrum objects like stars, galaxies, and reflection nebula, most other films will work.

http://www.astropix.com/HTML/I_ASTROP/FILM/FILMS.HTM#BADRED

Good Color Films to Shoot Unhypered

- Kodak Ektachrome E200 IPD Pro - A color transparency film for slides with an ISO of 200 that can be push processed to higher speeds with good results. Excellent h-alpha sensitivity. Kodak's consumer version of this film, Elite 200, has pretty much the same spectral sensitivity curves, so it offers a lower-cost alternative to the professional emulsion.
- Fujichrome Provia 400F RHP III Pro - A color transparency film for slides with an ISO of 400 that can be push processed to higher speeds with good results. Excellent blue sensitivity, very good red sensitivity. Fuji's consumer version of this film, Sensia 400, now seems to have very close spectral sensitivity curves to the 400F RHP, so it may be a good lower-cost alternative.

http://www.astropix.com/HTML/I_ASTROP/FILM/FILMS.HTM#BADRED

Good Color Films to Shoot Unhypered
(Continued)

- Fujichrome Provia 100F - A color transparency film for slides with an ISO of 100 with excellent red and blue sensitivity.
- Fujicolor Super HQ 100 - A color negative film for prints with an ISO of 100. Slow speed requiring long exposures, but excellent blue sensitivity.

Good Color Films to Shoot Hypered

- Kodak Royal Gold 200 RB1 - A color negative film for prints with an ISO of 200. Good red and blue sensitivity when gas-hypersensitized. Poor color response for long exposure deep-sky astrophotography when unhypered.

http://www.astropix.com/HTML/I_ASTROP/FILM/FILMS.HTM#BADRED

Good black and white films to shoot Hypered

- Kodak Technical Pan 2415 - A black and white negative film for prints. Very fine grained and high resolution. Produces a wide range of contrasts based on the developer choice. Excellent red sensitivity and good response across the rest of the spectrum. This film *must* be hypersensitized for long exposure deep-sky astrophotography. It has a film speed of about ISO 100 for long exposures when hypered.

http://www.astropix.com/HTML/I_ASTROP/FILM/FILMS.HTM#BADRED

Films with Very Low Hydrogen-Alpha Sensitivity

- Fuji Superia 400 and 800 - Color negative film for prints.
- Kodak Portra 400 and 800 - Color negative film for prints.
- Kodak Supra 800 - Color negative film for prints.
- Kodak Royal Supra 400 - Color negative film for prints.
- Kodak Max 400 - Color negative film for prints.
- Polaroid 400 - Color negative film for prints.
- New emulsion Kodak Royal Gold 400 - Color negative film for prints.

http://www.astropix.com/HTML/I_ASTROP/FILM/FILMS.HTM#BADRED

Getting Your Film Developed (1 of 2)

- There are only a few things that need mentioning here: tell the lab technician that you don't want the negatives cut. Most commercial labs have never seen astro-negatives and may assume that the frame is nothing but a grossly underexposed photo and accidentally cut through one of your hard earned negative frames. Also, it is a good idea to take along some magazine photos and explain to them that this is what you would like your prints to look like and that some custom adjustments to the printer may be called for to get similar results. If they seem uninterested, take your work elsewhere or you are going to pay for some badly printed photos.

Getting Your Film Developed (2 of 2)

- If they proceed with the processing and printing and the results are not what you wanted, then they should be willing to redo the work to get the results you want. You should be realistic, however, since if your negatives aren't good ones, they can do little to improve them. There is only so much that can be done with poorly exposed negatives to improve the prints, so fairness is the rule here.
- Some prefer to do their own processing to get exactly what they want.

Digital Astrophotography

Canon EOS Digital Rebel

Canon EOS 20Da

Deep Sky Imager

Color $299

Deep Sky Imager Pro

Monochrome $399

w Color Filter $499

CCD Camera

$300 - $500

$600 - $7000

Webcams

- Logitech Quickcam Pro 3000 or 4000
- Phillips ToUcam Pro (ToUcam 740)
- Phillips Vesta Pro

- Telescope adapters – webcaddy.com

Eyepiece Imager

Monochrome

& Color

$80 - $150

Video Camera

CCD Astrophotography (1 of 11)

1. Plan the objects to be imaged based on the field of view (FOV) yielded by the focal length of the optical system and the size of the CCD chip. The approximate width of the FOV in arcseconds can be calculated by dividing the width of the CCD chip in microns by the focal length of the optical system in millimeters and multiplying the result by 206. Similarly the FOV, or angular resolution, of each pixel can be determined using the same equation, substituting the width of a single pixel for the width of the entire CCD chip.
2. Polar align the scope or otherwise (if alt-az) set it up for accurate tracking. If no autoguider or manual guiding is used, then assure that well-tracked unguided exposures at least 15 seconds long can be made.

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3. Hook up the camera to the controlling computer, turn it on, cool it down, and mount it to the focuser of the telescope so that the chip can be positioned at the primary focal plane. It is good 1) to assure that the entire chip is fully illuminated by the primary mirror (no vignetting), 2) to mount the camera to a swivel or a slide so that the camera view can be interchanged with an eyepiece view for object centering, 3) to have a large finder scope with center reticle well-collimated with the primary scope to allow quick finding and centering of objects, and 4) to have some sort of focusing aid (Hartmann or diffraction mask, focus mode non-ABG blooming, etc.); but NONE of these things are mandatory! They are handy and are highly desirable, but you can make dandy images struggling along without them at first!

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4. Set the camera to the binning mode and other settings appropriate to the imaging plan.
5. Center a medium-bright star (3rd-7th magnitude, depending on the size of the scope) in the camera FOV, put the camera in focus mode (if available), and focus the star as best you can. Lock the camera/focuser into position and/or mark it for easy return.
6. Center the object to be imaged in the FOV and take test exposures to assure good tracking, focus, and framing. Determine the maximum exposure duration usable for the tracking and pixel saturation limitations. Cameras without anti-blooming will allow bright stars to bloom and this should be minimized as much as possible, but without sacrificing the usable exposure duration needed for acceptable signal-to-noise-ratio (SNR).

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7. Cover the camera's optical window so that NO light can reach the chip and take a dark frame the same exposure duration as your light (object) frames. Depending on your setup, either the camera itself, the bottom of the focuser, or the front end of the scope may be covered to achieve complete darkness. The acquisition software should allow the dark frame to be stored in a buffer so that it can be subtracted from light frames as you take them to allow you to really see what you are getting in your images.
8. If imaging a faint deep-sky object, take MANY MINUTES of total exposures so that a very good SNR image can be processed later. Take several dark frames over the course of the night so that these can be averaged later into a good master dark frame for high-quality processing.

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9. If using a vignetted optical system or a telecompressed SCT (especially if used under less-than-very-dark skies), take flat-field images using a light box or a very evenly illuminated "surface", such as a smooth wall, a large posterboard, or a twilight sky. Flat-field frames are made with the scope looking into the dimly-lit light box or at the dimly illuminated "surface“ and result in an image of the optical and CCD array itself. Make sure that flat-field frames are made with the camera in exactly the same focuser orientation and position as in the object frames. Flat-field images need only be a few seconds long, just long enough to raise the pixel values to about 20-50% of saturation. Take several so that they can later be averaged. Take several dark frames the same exposure duration as the flat-field frames so that they can later be averaged and used to calibrate the master flat-field frame.

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10. If doing "true color" imaging, make sure to use an IR blocking filter for all color-filtered images. Take a few minutes' worth of exposures through each filter after taking the unfiltered (or IR blocker only) images, carefully checking the focus through each filter. If flat fielding is necessary don't forget to do it for each filter!

11. Use astronomical image-processing software to calibrate, stack, and otherwise process your raw CCD images to bring out the objects of interest (nebulae, star clusters, etc.) so that they can be seen in detail with appropriate brightness, contrast, range of grayscale, and (if applicable) color balance. Image processing and software experts such as Richard Berry, Bruce Johnston, Michael Newberry, Douglas George, and Christian Buil (and others) have all written full-range programs which may be capable of reading and manipulating the raw images from your camera.

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12. The first step in processing is to calibrate the light frames. This means to remove unwanted signal and reduce noise factors in the object images and it is accomplished by subtracting a dark frame from the light frame and, if needed, dividing a mathematically normalized flat-field frame into the light frame (see subsection b. under the section called Processing Images). Before calibrating the light frames, create a good master dark frame by averaging several darks taken at the same exposure duration as the light frames. Save the master dark frame and use it to accomplish the dark subtraction. Similarly, create a good master flat-field frame by averaging several flat-lights and averaging several flat-darks, then subtracting the master flat-dark from the master flat-light.

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13. After the images have been calibrated, short exposures of the same object can be stacked (averaged) to create, in effect, an image of longer total exposure duration and much higher SNR. Use your software to register/rotate the subexposures as necessary to assure that all objects in the images (stars, nebulae, etc.) stack exactly on top of themselves. Short subexposures often benefit greatly by being scaled linearly (all pixels in the array multiplied by a constant) before being stacked. Depending on how the software mathematically accomplishes the stacking, this will increase the number of grayscale levels in the object of interest. Save the calibrated stack as a FITS image.

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14. If color-filtered images were made to produce a color composite image, calibrate and create each color stack. If a scaling factor is used during stacking, be sure to use the same scaling factor for all color stacks so that the subsequent color balancing process is not affected.
15. If the CCD pixels are not square, resample the images appropriately to correct the aspect ratio. Process the calibrated final unfiltered (white) image using linear and/or nonlinear scaling functions to bring out desired details, brightness, and contrast in the objects of interest. In addition, filtering functions may be used to soften and/or sharpen details in the image.

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16. If color-filtered images were made, scale the stacked data to color-balance the RGB image sets in accordance with the relative RGB sensitivity of the chip/filter system. If CMY filters were used, convert the image data to RGB image sets using CMY color compositing software before color-balancing the RGB images. Neutralize the effects of foreground sky color (from light pollution, etc.) by normalizing the sky background pixels in the RGB images to the same low ADU value. Register and composite the white image with the RGB images using luminance-layering color composite techniques. Once processed/composited to satisfaction, save the image as a TIFF.

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17. Use general graphics processing software, such as Paint Shop Pro or PhotoShop, to load the TIFF image, enlarge (resample), rotate, crop, adjust gamma, adjust brightness and contrast, and/or apply further functions to produce the desired final product. Save as a least-loss JPEG to retain a high-quality image in a small file size.

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References

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