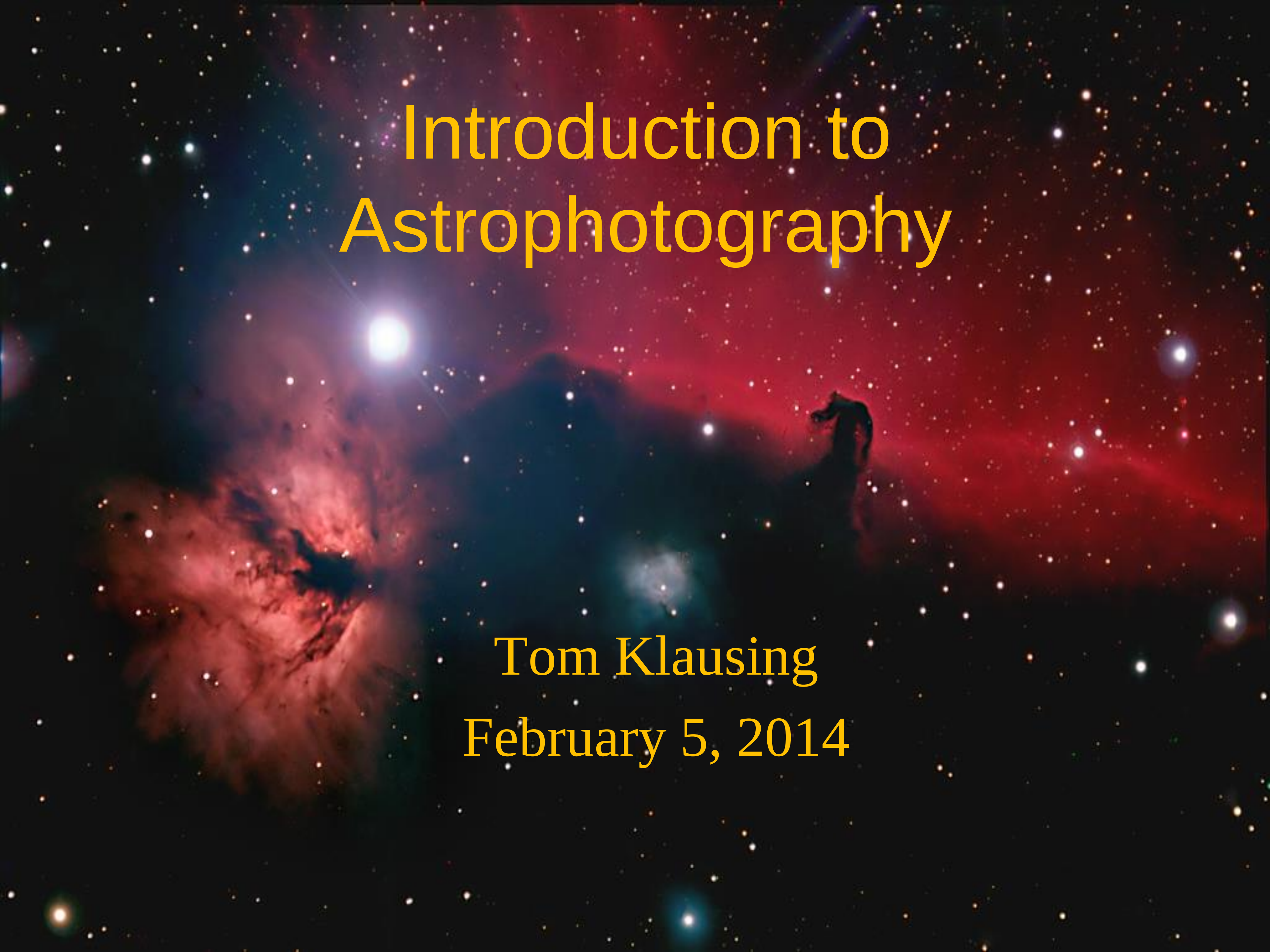
Introduction to Astrophotography



Tom Klausing

February 5, 2014

Imaging Setup for Horsehead Photo

AP1200 Mount, 130 mm Refractor, 780 mm FL, CCD camera

How I Got Hooked

- I’m a retired Battelle engineer
- Been interested in photography since the 1960s
- Still have lots of analog gear in my basement (I am better at buying than selling)
- Began astronomy as a hobby about 15 years ago
- I tried to stay away from astrophotography for as long as I could because I knew it would be addictive, but got hooked a couple of years later
- I do most of my astrophotography from a reasonably dark private site we call Hutville, which is located about 25 miles from Columbus (more on this later)

Your Background and Interests

- Questions and Answers

Topics (It’s a huge subject, impossible to do it justice in one session, even if I actually knew what I was talking about)

- Why astrophotography?
- What is it?
  - Views of the night sky
    - Milky Way
    - Star Trails
    - Aurora
  - Solar system views
    - Sun
    - Moon
    - Planets
    - Comets
  - Deep sky views
    - Star clusters
    - Asterisms
    - Galaxies
    - Nebula
- Examples, equipment, and software
- Getting started

Why Astrophotography?

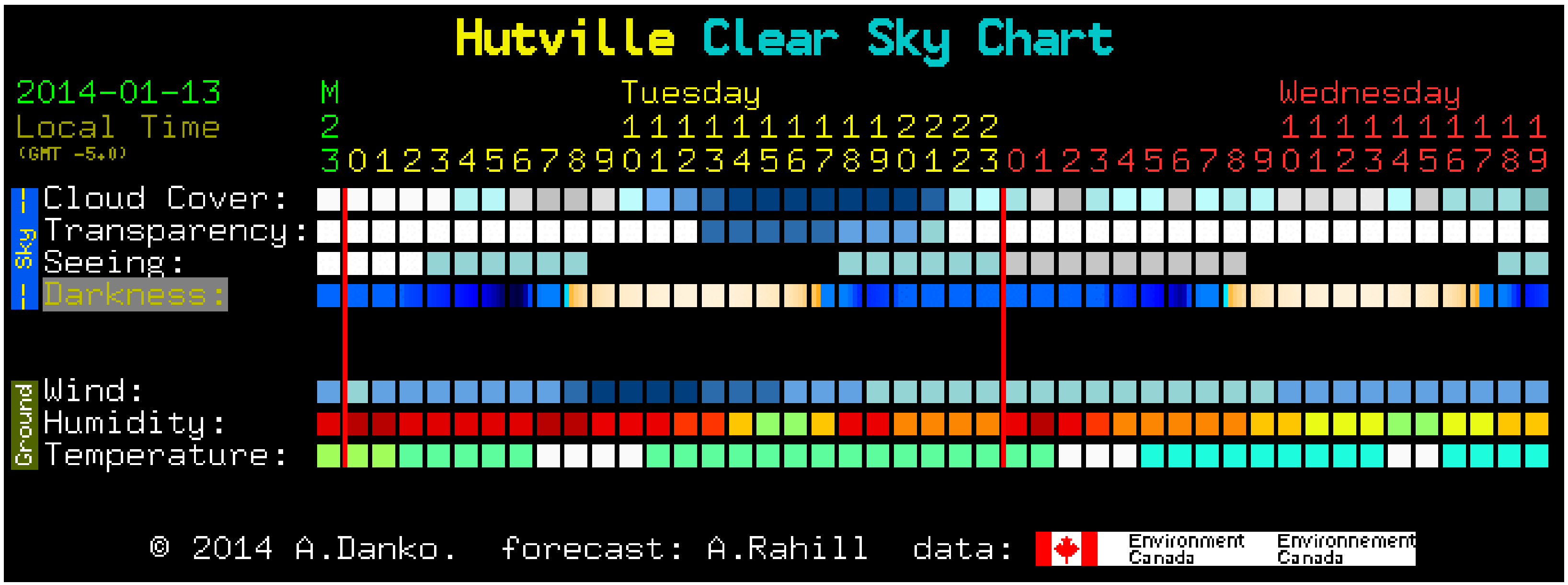
- The earth is just a tiny spec in the universe, so why not go for the bigger picture?
- You can have a great interest in the science of astronomy, or you can just love the views and photographic opportunities, or you can combine the two.
- Astrophotography can provide tremendous technical challenges for those that are so inclined.
- You can start with equipment you already own (but be very careful because this can be a very slippery slope)
- Being outdoors under the night sky in a dark location can be a great experience (just don't forget your cold weather gear).
- Digital imaging and modern image processing software have made it possible for amateur photographers to obtain astronomy images that can be as good and sometimes better than the images in the books on your coffee table taken by commercial observatories that were published several decades ago.
- And one of the most significant points -- the ability to image objects that can't be visually observed with the naked eye or even with the largest of telescopes

The Night Sky – Four Key Quality Factors

- Clear Skies
  - Clouds can improve daylight images of the sky, but seldom improve night sky imaging
  - Too bad we live in Ohio!
- Dark Skies
  - For most observing and imaging purposes, dark skies are very helpful
  - Avoid city lights. The light dome over Columbus can be seen from 30 miles away.
  - Ohio isn't a good location for dark skies, but there are a few areas that are not too bad, mostly in southern Ohio. There are several good online maps showing dark sky areas in the US
- Transparency
  - Even on a cloudless night, dust and moisture in the air reduce the clarity of the sky
  - Again, Ohio isn't the best location
  - Winter skies often have better transparency
- Seeing
  - "Seeing" is a term used to describe the steadiness of the atmosphere. Unsteadiness in the atmosphere can be seen as twinkling of the stars.
  - Thermal gradients are a key cause of poor seeing
  - Good seeing is important for high resolution imaging

A Website with Night Sky Forecasts
Cleardarksky.com

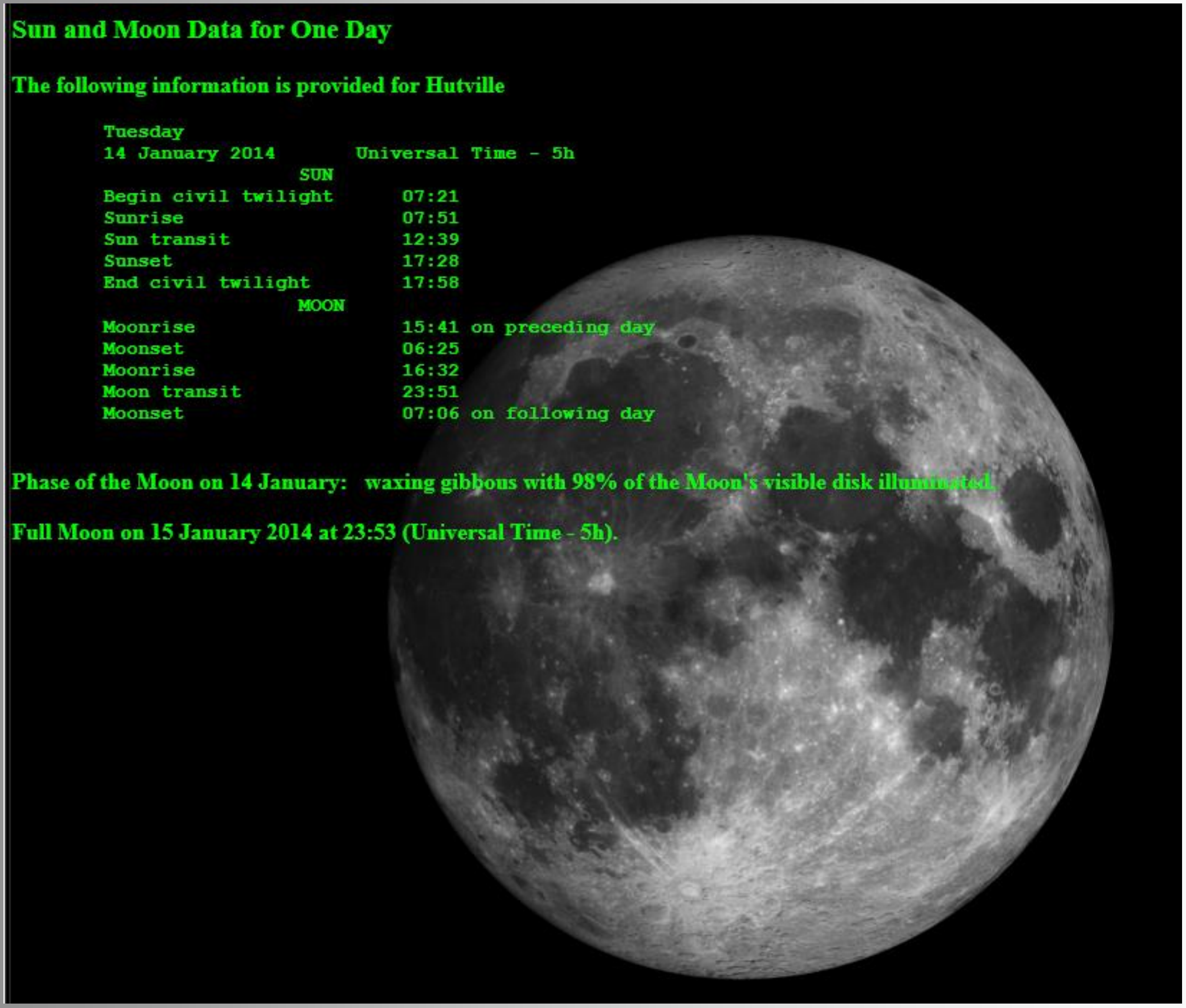
Last updated 2014-01-13 23:26:46. No Image below? Read this. Not showing todays data? Clear your cache.



Hutville is located on private property located between Columbus & Mt.Vernon, Ohio.

Cleardarksky.com has forecasts for hundreds of locations around the country, including nearly 100 sites in Ohio

A Website with Night Sky Forecasts, Cont. Cleardarksky.com



Hutville Site

- It really helps to have dark skies. Ohio isn’t the ideal location for dark sky imaging, but getting away from the cities is still helpful.
- Don’t panic. You don’t need a facility like this to do good astrophotography, and you don’t need all this equipment either.
- The Hutville photos are just to give you an idea of where the slippery slope can lead. Beware.

Hutville Star Party

My Roll-off Roof Observatory at Hutville

My Roll-off Roof Facility at Hutville

Imaging Setup
AP1200 Mount, 14”SCT, 4” Refractor, CCD Camera

Imaging Setup
AP1200 Mount, 14”SCT, 4” Refractor, CCD Camera

Views of the Night Sky

- Broad scale images of the night sky are the probably the most common astronomical subject for most photographers (very popular in recent digital camera years)
  - Great results can be obtained without specialized equipment
  - A tripod mounted DSLR can be used with lenses of a variety of focal lengths (depending on the field of view intended)
  - Wide angle lenses are often used to good effect and are easiest to use
  - Many of the most interesting images include terrestrial foreground objects
  - Exposures for the night sky will vary according to the subject type
- Unless star trails are intended, exposures times should be less than 30 seconds when wide angle lenses are used and even shorter if longer lenses are used
- The use of higher ISO settings will often give better results when trying to obtain pinpoint stars (ISO 800 to 1600 are typical values)
- If needed, multiple exposures can be aligned and combined to achieve better signal to noise ratios
- Exposure requirements for foreground objects may differ from the night sky requirements, and often the best results are achieved by combining images (a good opportunity to use the Photoshop skills you have been practicing)
- A tracking mount is required to prevent star trails with longer exposure times
- **Dark skies are the key! Great opportunity for you folks that travel!**

Night Sky Example – Milky Way with Foreground (from the Web)

Another Night Sky Example from the Web
(I wish I could claim it)

Yet Another Night Sky Example from the Web

Night Sky Example – Star Trails (from the Web)

Night Sky Example – Star Trails, Combined Exposures (from the Web)

Night Sky Example – Aurora at Hutville, Canon 10D

Solar System Images

- Most solar system objects are relatively bright and therefore the complications associated with long exposure times are avoided.
- Since solar system objects are bright, dark skies are not required. The sun, moon, and planets can be imaged even from city and suburban locations.
- This doesn’t mean your photographic skills won’t be challenged.
- The key to solar system imaging is resolution. This is one case where good “seeing” trumps dark skies.

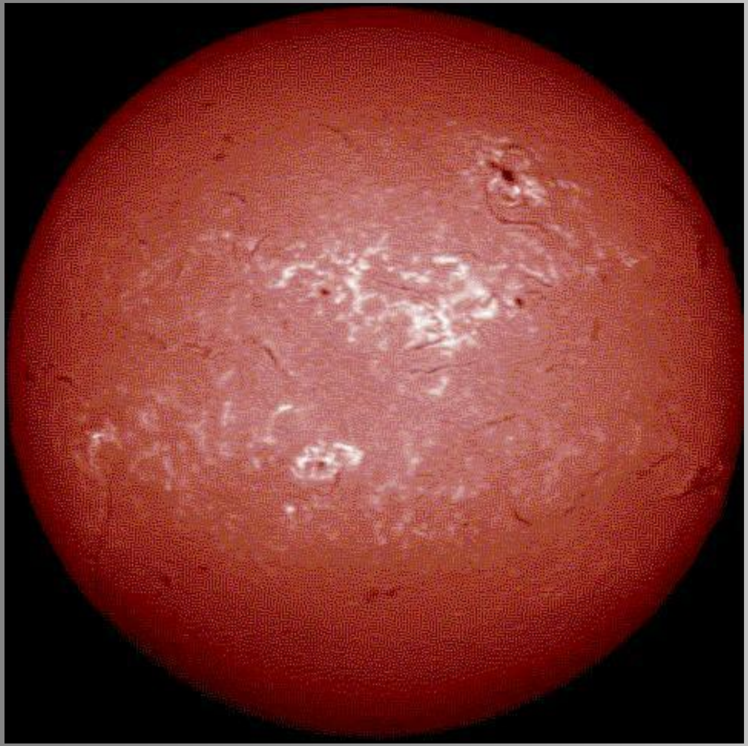
The Sun

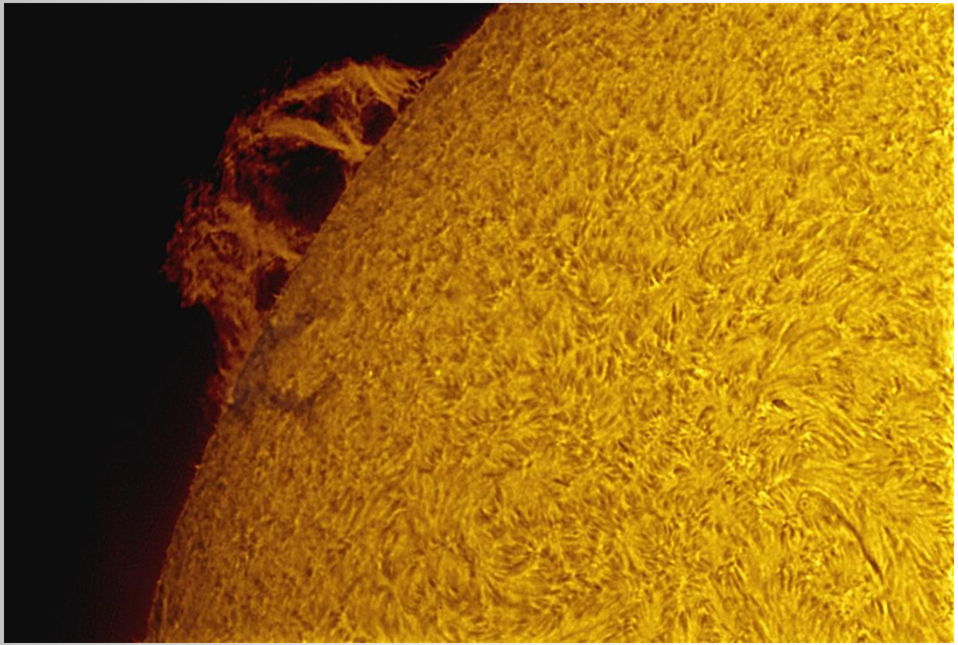
- In case you didn't notice, the sun is a bright object (at least it appears that way on those few Ohio days when the sky is clear)
- The most common images of the sun are of the sunset or sunrise variety and are not usually thought of as astrophotography
- Images specifically of the sun are generally taken through long lenses or telescopes equipped with white light solar filters or narrow bandwidth H-alpha (656 nm) filters so that interesting solar effects such as spots or flares are highlighted.
- Solar images can be obtained with a DLSR attached to a tripod mounted long lens or telescope that is equipped with some version of a specialized solar filter. Focal lengths of 400 mm and up are best to achieve reasonable image size. **Never point your long lens or telescope at the sun without a solar filter.**
- Solar filters are priced according to the type and how narrow the bandpass is that they provide. Very narrow bandwidths can be very expensive. A conventional thin film white light solar filter for a 4" refractor might cost $100. A sub-angstrom bandwidth H-alpha filter might cost $5000.

Venus Transit of the Sun (2012)

Canon 30D, AP 130 mm Refractor, 780 mm Focal Length, White Light Solar Filter

Solar Images (Narrow Bandwidth H-alpha)
(from the net)





The Moon

- While it may seem “common”, the moon is a fantastic photographic subject, and one that most photographers have probably imaged.
- Dark skies and special equipment are not needed since the moon is a large bright object.
- The moon is a “daylight” exposure subject, so tracking mounts and long exposures are not needed.
- Long focal length lenses (400+ mm) are useful if details of the moon’s surface are the main objective.
- Shadows and depth on the moon’s surface are not shown to best advantage when the moon is full. Partial phases of the moon can provide great depth and interesting detail near the lunar terminator.
- The exception to daylight exposures is during lunar eclipses, which are much more common than solar eclipses, and provide great photographic opportunities.

Typical Lunar Image

Canon 7D, TeleVue NP101 Refractor, 540 mm, f5.4, 1/640 sec

Full Lunar Eclipse

Canon 10D, 11” SCT Telescope, 2800 mm FL

Planetary Imaging

- Normally, planetary imaging implies imaging of Jupiter, Saturn, or Mars.
- These are “high resolution” targets.
- Planets are small but bright objects, so you don’t need dark skies, but you do need good “seeing”.
- Best results with very long focal lengths (leave your 70-200 mm lens in the bag).
- One option is a long focal length telescope combined with a barlow (teleconverter).
- Another option is imaging through a telescope or spotting scope combined with an eyepiece (eyepiece projection).
- Since the objects are small but bright, small pixels are more helpful than large sensor size.
- Because atmospheric distortions cause variable seeing, best results are often achieved by processing a large number of images (from a few hundred to a few thousand) and these are often obtained by shooting videos. Planetary image processing software is used to analyze the hundreds or thousands of images, select the sharpest ones (those obtained during the brief periods of steady atmosphere), statistically combines these, and then enhances the combined image.
- Several versions of small web cameras have been popular for planetary imaging.
- DSLRs with small pixels also work well in the video mode.
- The key to good results is image processing (as usual).

Celestron NEXIMAGE 5 Solar System Imager
$199, 2.2 micron pixels, includes software

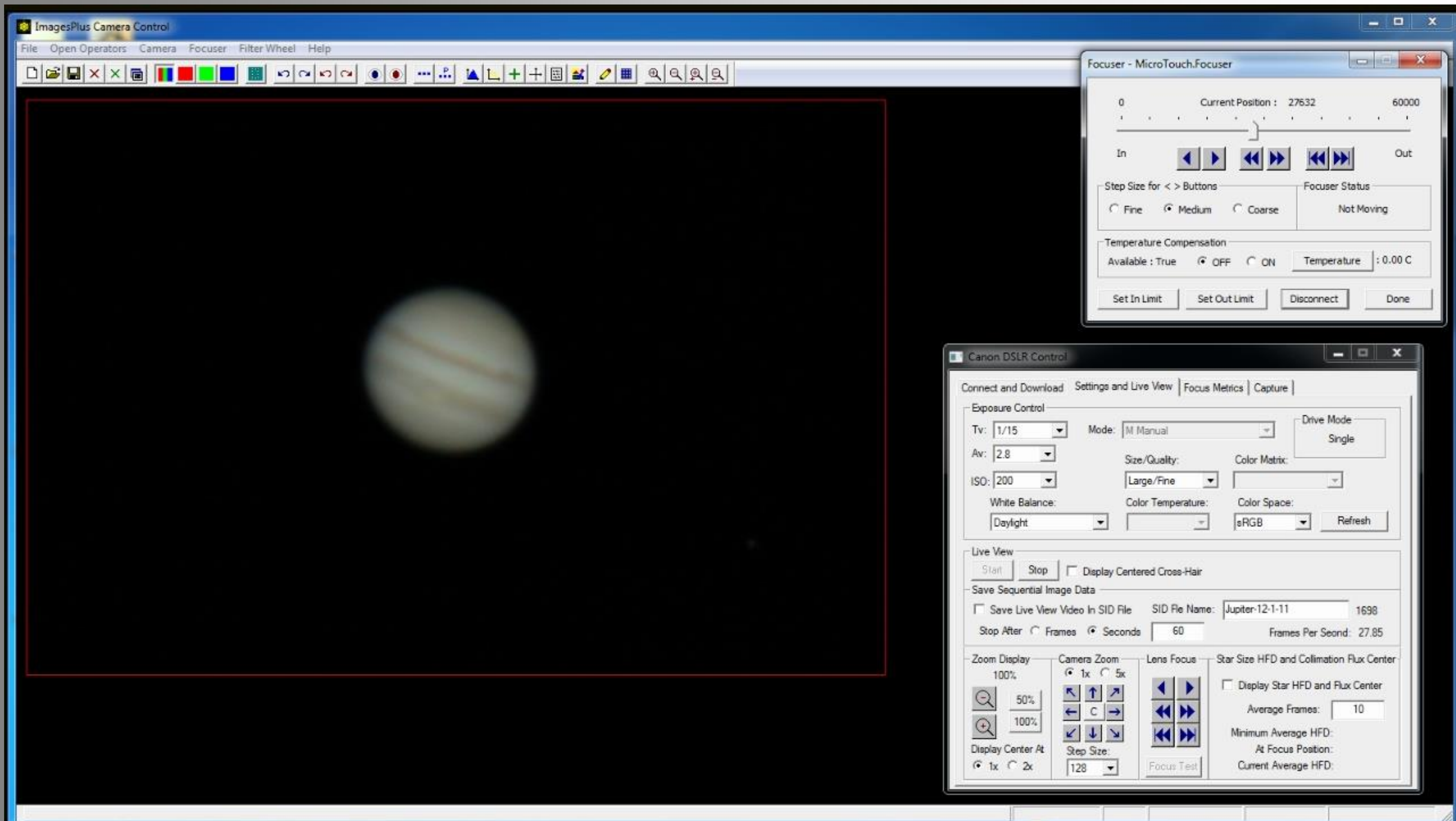
- 5 Mega pixel color sensor with Micron® DigitalClarity® technology to dramatically reduce image noise levels
- Software automatically filters out video frames most affected by poor atmospheric conditions, leaving only the sharpest, clearest frames to be stacked and aligned into one high-quality image
- View and capture live video on your computer
- Manually adjust gain, contrast, exposure time, frame rate and color saturation using your PC
- Machined aluminum 1.25" adapter barrel with C-threads for direct threaded connection to almost any telescope

Planetary Imaging Cont.

- A variety of software programs are available to help automate the processing of planetary image data. These range from shareware applications (such as Registax) that are specific to planetary and lunar imaging to subsets of larger commercial imaging software packages, such as ImagesPlus or BackyardEOS. Many of these applications control the camera as well as process the images.
- These applications usually have the following common steps:
  - Assist in achieving focus
  - Set camera parameters for exposure, frame rate, etc.
  - Acquire and save data (typically 1000 or more frames)
  - Grade the images and then down select a subset of the sharpest images (perhaps 5 to 10 percent of the total)
  - Calibrate, align, and statistically combine the subset of best images
  - Enhance the combined image
    - Levels, curves, micro-curves
    - Sharpen, noise reduction, etc.
    - Color balance, saturation, etc.
    - Etc., Etc., Etc.
- A few screen shots from the ImagingPlus tutorial follow. The sample images in the tutorial were shot with an 8 inch aperture apochromatic refractor ($$$$$), with a barlow to achieve a focal length of 3700 mm. Camera was a Canon T1i DSLR ($).

Canon live view video is used to capture and store 1900 uncompressed frames of Jupiter at 23-28 frames per second using ImagesPlus camera control.

Then ImagesPlus image processing is used to sharpen, and enhance the best frames .

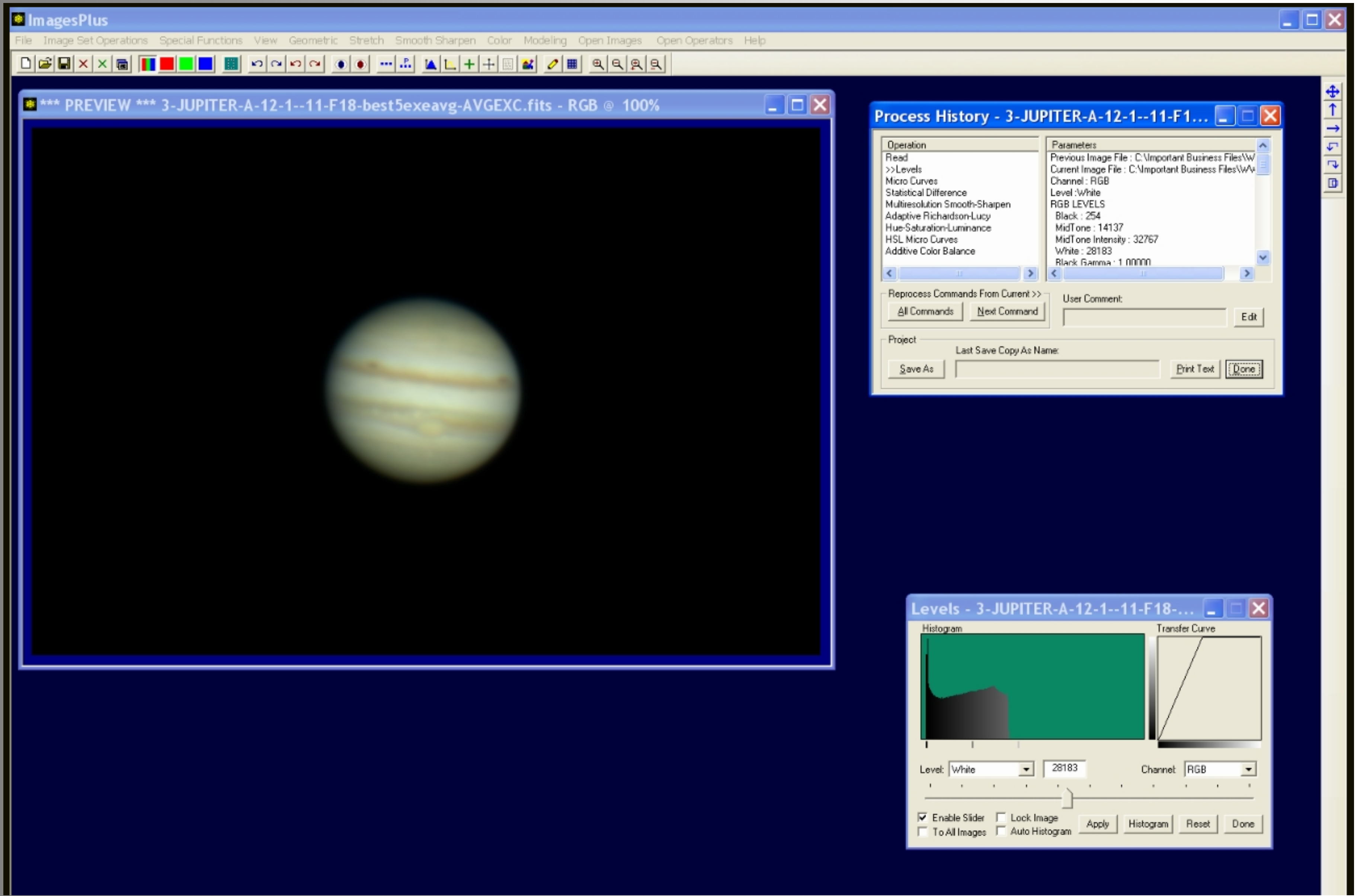


Canon live view data being captured and saved as uncompressed 24 bit per pixel data in a SID file called Jupiter-12-1-11.sid using ImagePlus camera control. The SID file will be graded, aligned, stacked, and enhanced using the steps shown below.

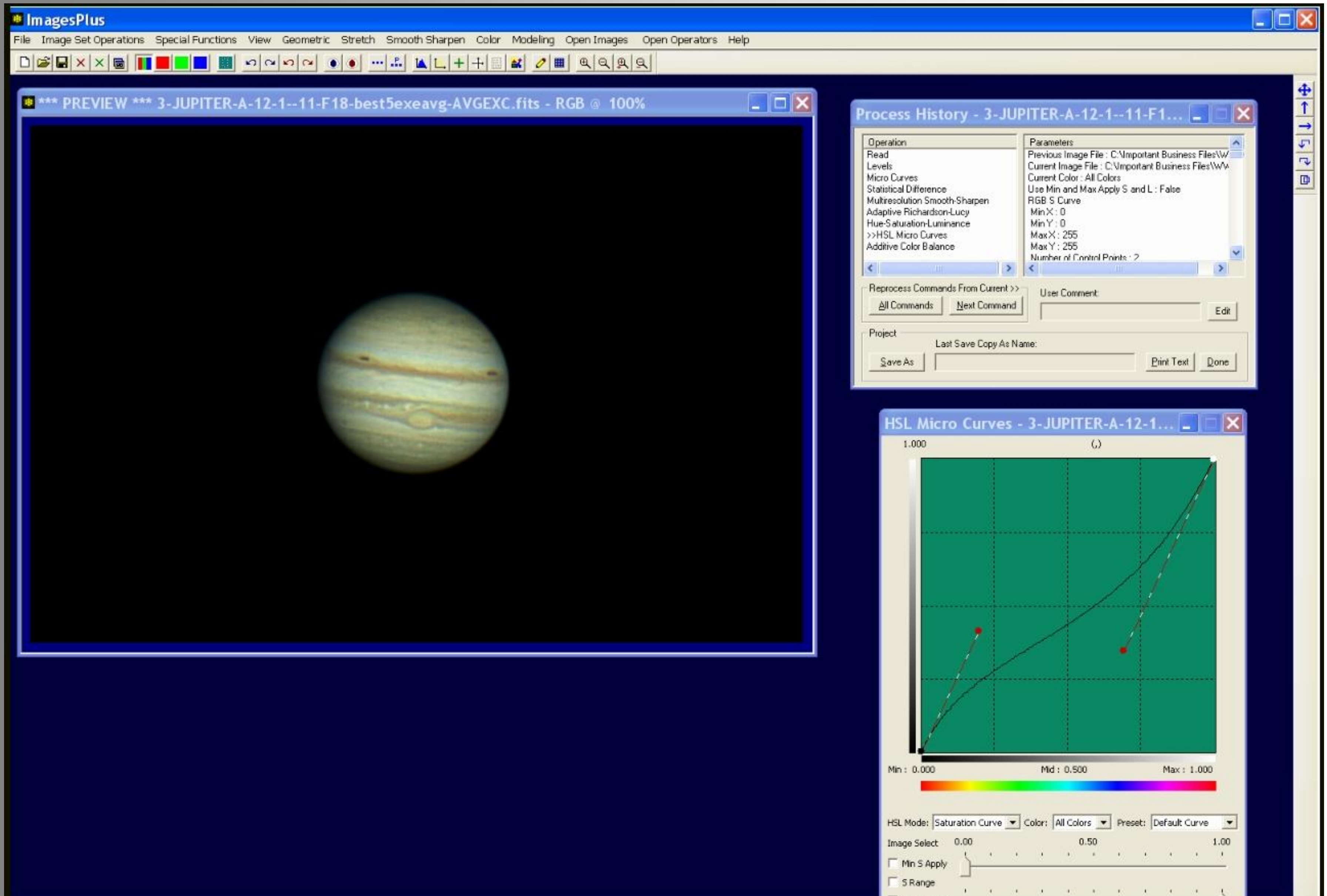
Setting up to Grade 1900 Images

Only Grade A is checked and set to 95 to select only the best frames with a grade of 0.95 to 1.00 from 1900 frames. The Grade, Align, and Combine boxes are checked to turn on grade, align, and combine processing.

One of Many Processing Steps on the Combined Image



Nearing the Final Result



Comets

- Comets are popular astronomy subjects that draw attention even in the popular press (recently, comet ISON has been in the news, but it was a bust).
- A comet is an icy small solar system body that, when passing close to the Sun, heats up and begins to outgas, displaying a visible atmosphere or coma, and sometimes also a visible tail.
- Unlike the sun, moon, and planets, comets are typically not bright objects and can be quite challenging to photograph.
- Short exposures will not bring out the comet's surrounding coma or it's tail.
- Long exposures (more than a few seconds) will require a tracking mount. But if the mount is tracking the stars, the comet head will show motion due to its movement through the solar system.

Comet Image (from the Web)

Deep Sky Imaging

- Deep sky imaging usually refers to imaging objects that are beyond our solar system (in other words, 99.9999999…… percent of the universe).
- This is my favorite area of astrophotography due to the variety and beauty of the subjects.
- Imaging, even with modest equipment, can reveal color and detail in many objects that can't be visually observed even through large telescopes.
- Most of the deep sky objects are of low brightness and require tracking mounts and longer exposures to achieve good results. Autoguiding is often needed for best results
- Dark skies are helpful in most cases. Moonless skies are best.
- One interesting thing to keep in mind, is that the only things we can image or observe that are outside of our own Milky Way galaxy are other galaxies. All of the stars, clusters, nebulas, etc. that we can observe are part of our own galaxy, which is only one of the billions of galaxies in the universe.
- The next few slides will provide a few examples of deep sky images. Then equipment and software options will be discussed as time permits.
- Apps for your smartphone or tablet computer can make it easier to find objects in the sky.

Andromeda Galaxy (M31)
(AP130 refractor, Canon 10D, 5x500 sec images)

Orion Nebula (M42)
NP101 Refractor, Canon T4i, 17x180 sec

Horsehead Nebula and Flame Nebula (AP130 Refractor, ST10XME, RGBHa

Rosette Nebula
TeleVue 60 Refractor, 360 mm FL, ST10XME, RGBHa

Crab Nebula (M1)
C14 at 3000 mm, ST10XME, RGBHa

Helix Nebula (NGC7293) by Isaac Cruz
LRGB 20x600 sec

Supernova In M82 (Imaged by Isaac Cruz last week at Hutville)

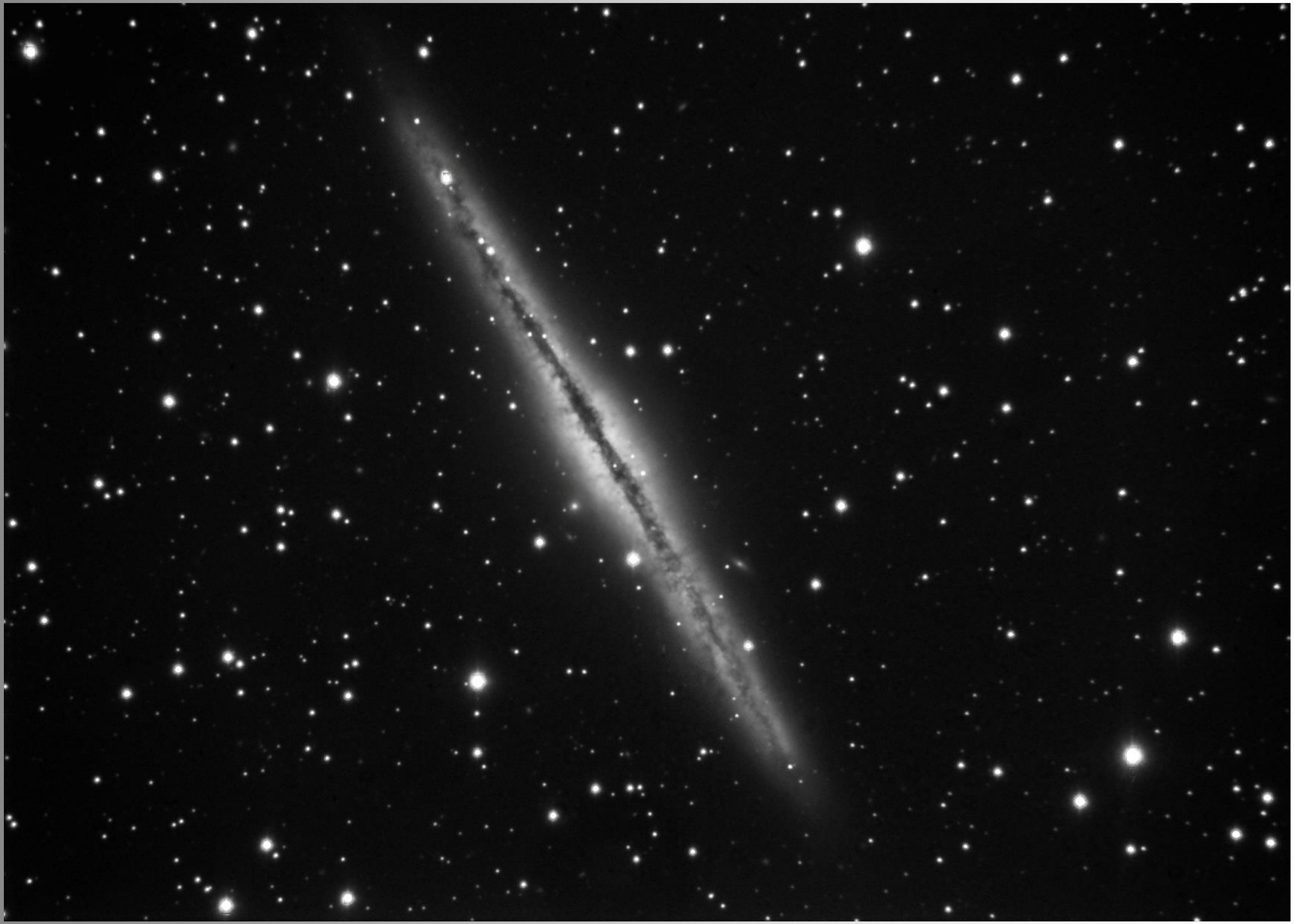
Bubble Nebula
C14, ST10XME, 9x600 sec Ha

Pillars of Creation (M16)
C14, ST10XME, 9x600 sec Ha

Pillars of Creation (M16)
C14, ST10XME, LRGB

Veil Nebula (NGC6992)
NP101 refractor, ST10XME, HaLRGB

NGC891
C14, ST10XME, Luminance Only

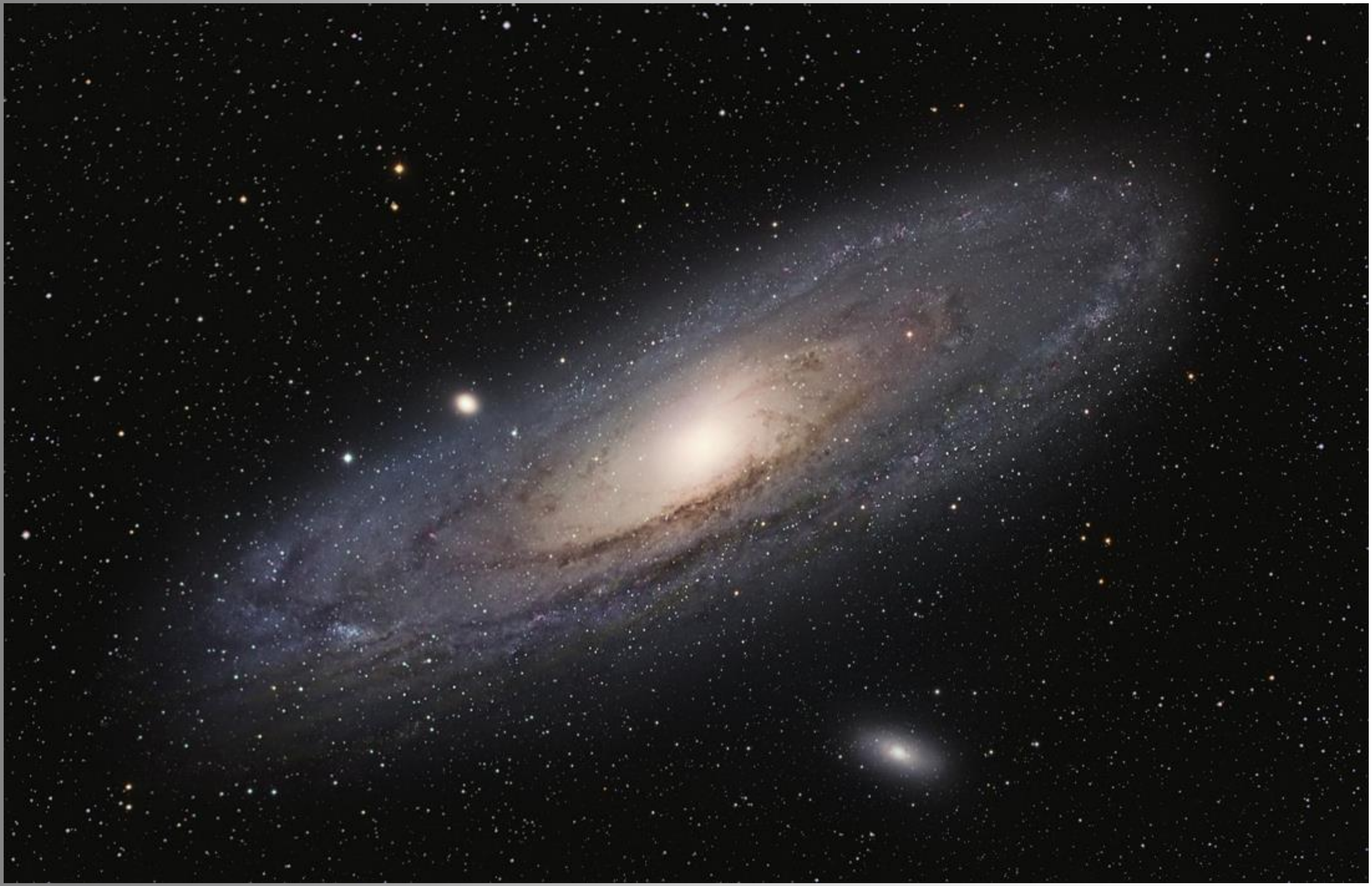


NGC7331
C14, ST10XME, 21x300 sec Luminance

M92
C14, ST10XME, 13x300 sec Lum

Andromeda Galaxy (M31) by Joe Renzetti

Celestron HD1100 SCT with Hyperstar (800 mm, f3.0), Canon T3i (modified)



M42 Region by Joe Renzetti

Celestron HD1100 SCT with Hyperstar, Canon T3i (modified)

Cameras for Astro Imaging

- A wide range of cameras types can be used successfully for astrophotography. As expected, some types are better than others for certain applications. Remember that camera mounts are at least as important.
- Point and Shoot Digital Cameras
  - Can be quite decent for wide field night sky images
  - Can be very good for moon and planetary imaging when used in digiscoping mode
- DSLRs
  - Excellent for wide field night sky images
  - Excellent for solar and moon images when coupled to long focal length lenses or telescopes
  - Excellent for planetary imaging if used in video mode with long focal length telescopes
  - Decent for deep sky images if used with appropriate camera control software
  - Very Good for deep sky images if modified for full bandwidth sensitivity
- Astrophotography Specific CCD cameras
  - Can be used for solar, moon, and planetary images, but not ideal
  - Excellent for deep sky images due to high sensitivity and cooled and temperature controlled sensors. Available in one -shot color versions and monochrome versions
  - Most CCD cameras are monochrome with a filter wheel used to provide RGB and narrow bandwidth filter options
- Film Cameras
  - Forget it !

DSLR Cameras

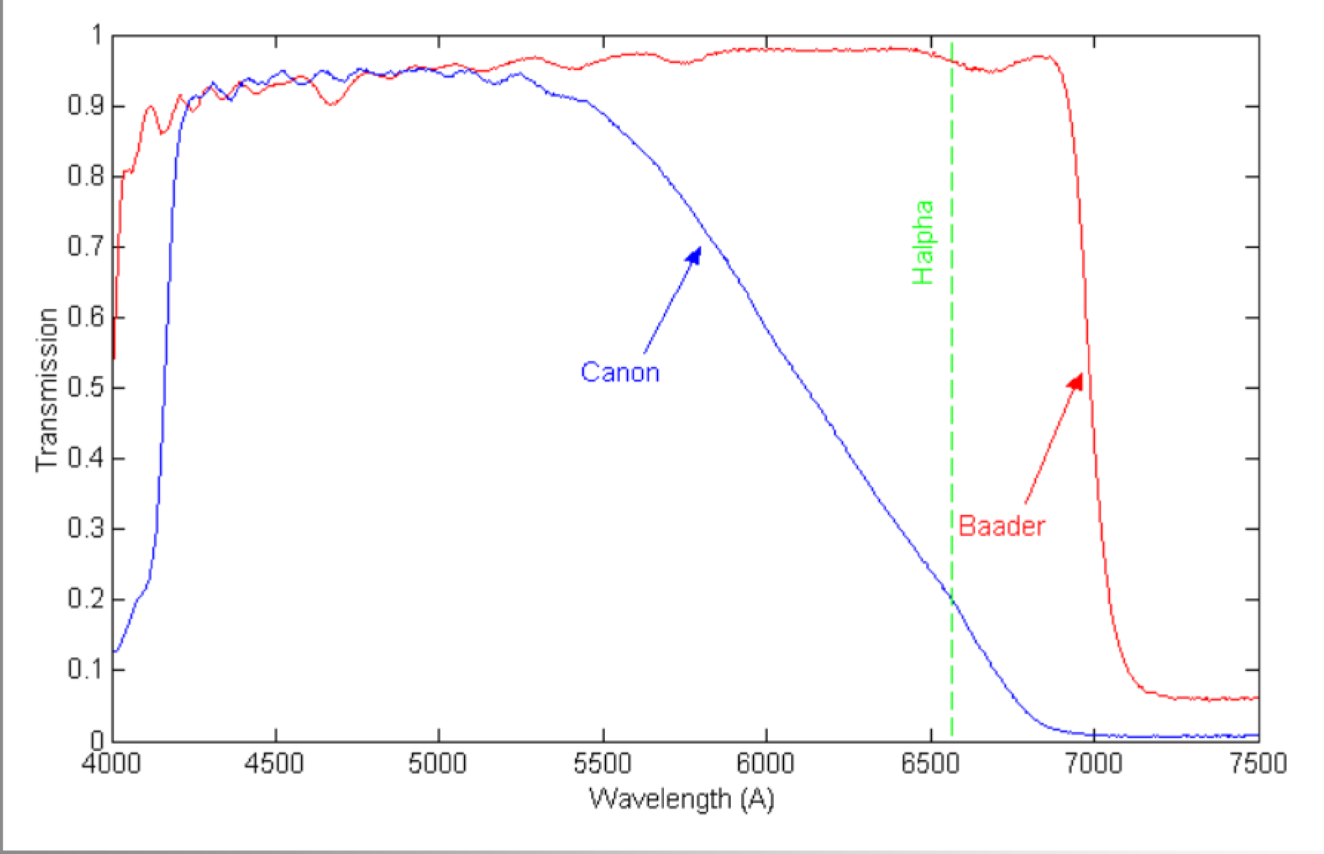
- For wide field night sky imaging, most DSLRs can give great results. Use what you already have, just make sure you use a good tripod and bracket exposures when possible.
- For most solar, moon, or planetary imaging, conventional DSLRs work great. Good optics, small pixel size, and live view mode are the key factors. A tilt/flip LCD screen can be very useful when the camera is pointing upward.
- For deep sky images, DSLRs must be mounted on a tracking mount, either directly or piggybacked on a conventional telescope.
- DSLRs can be used with conventional camera lenses or with telescope optics, depending on the field of view desired.
- DSLRs are attached to telescope optics by the use of the traditional T-mount adaptors that are available for most cameras. The T-mount is attached to a telescope compatible nosepiece (either of the standard 1.25” or 2” diameters)
- For deep sky images, low dark noise and minimum amplifier glow are key issues. Again, the tilt/flip LCD screen is an advantage due to viewing ease and the ability to move the LCD screen away from the camera sensor to reduce heating effects.
- Sensor noise during long exposures is directly proportional to sensor temperature. To reduce dark noise effects, dark frames are used. The dark frames are most effective when taken at the same sensor temperature as the light frames.

DSLR Cameras, Cont.

- Due to their low brightness, most deep sky objects benefit from very long exposure times. In the days of film cameras (remember those?) single exposures of one hour or more were often used in an effort to get adequate signal to noise ratios.
- With digital cameras (either DSLR or CCD) it is more common to combine (statistically combine, not additive) a significant number of shorter exposures. Typically individual exposures of between 30 seconds and 10 minutes each are combined to accumulate one to as many as ten or more hours of data.
- Software applications are used to calibrate the individual exposures (apply darks, flats, and bias corrections) and then align the individual exposures and perform the combining statistical functions.
- Many of these same software applications can be used to control a tethered DSLR via the USB connection. This software can assist in obtaining optimum focus and then permits the operator to use the computer to set up sequences of exposures to automate the time consuming data acquisition process.
- A number of software packages are available to assist in astro imaging with DSLRs, some are freeware, some are commercial packages. An example of a low cost program is BackyardEOS. This program costs $35 and offers good tethered control of a Canon DSLR on a Windows based computer.
- Two of the most popular commercial packages are ImagesPlus and Maxim DL. Both programs provide remote automated control of all popular DSLR and CCD cameras, and both packages provide sophisticated data combining and image processing features.
- In the earlier years of DSLR cameras, Canon cameras such as the Canon 10D, 20D, and Digital Rebel cameras were the most popular for deep sky imaging because they had significantly lower dark noise and amplifier glow levels than other camera brands when used for very long exposures.
- Nikon fans can relax now. In recent generation cameras, there is little to choose between the two brands for deep sky imaging.

Modified DSLR Cameras

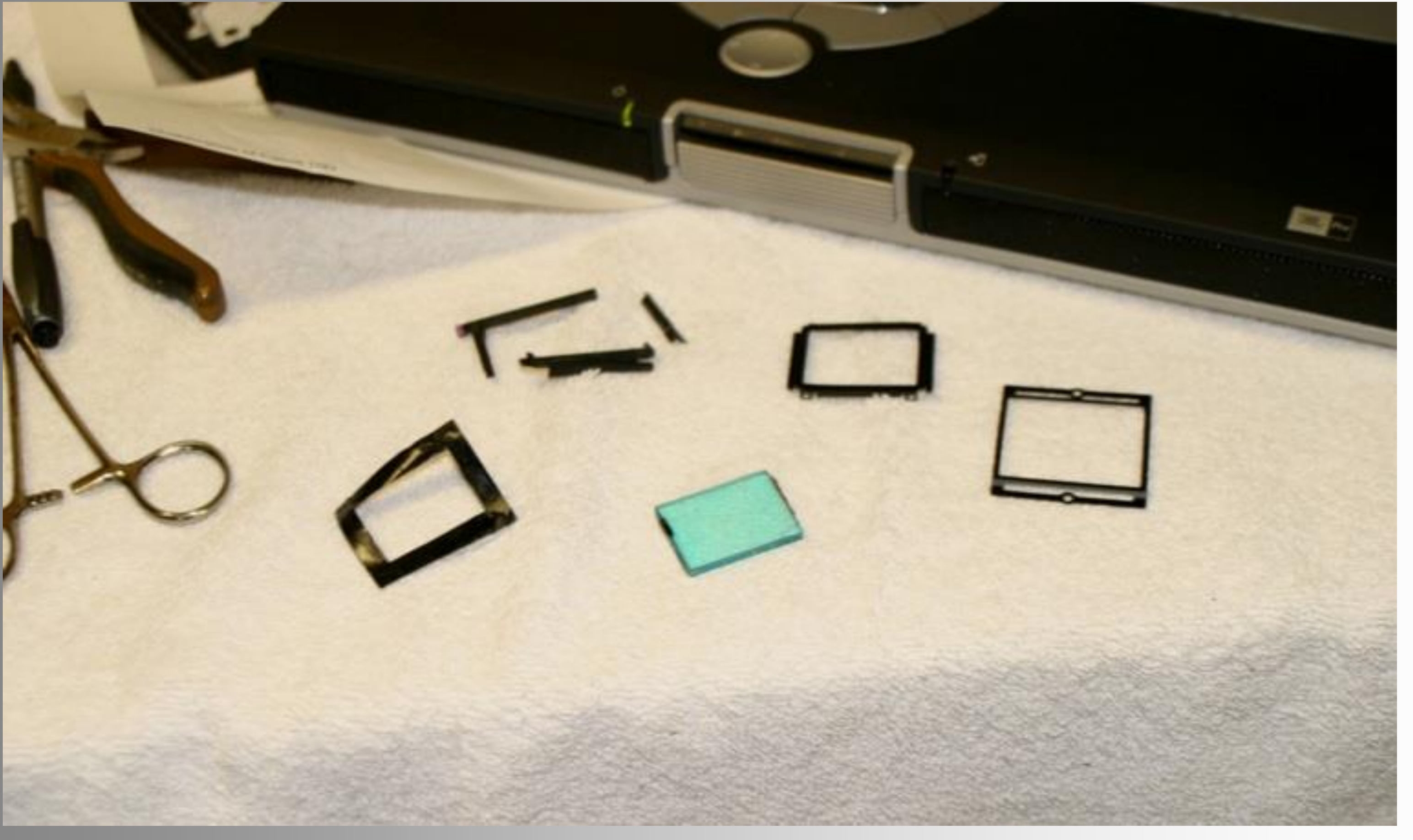
- With the exception of the Canon 20Da and 60 Da cameras (special Canon models for astrophotography), DSLRs have a UV/IR blocking filter in front of the sensor that greatly reduces the sensitivity of the sensor in the deep red region which includes the critical Hydrogen-Alpha (Ha) wavelength (656 nm) that is the basis for much of the nebulosity that we image.
- Many deep sky imagers use DSLRs that have been modified to give increased sensitivity to the deep red wavelengths that are so important in many deep sky objects. Modifications can involve simply removing the filter or replacing it with one that improves the deep red response.



Canon Camera Modifications for Astrophotography
No Guts, No Glory

Canon Camera Modifications for Astrophotography
The Offending Filter

Canon Camera Modifications for Astrophotography
Always a Few Parts Left Over



CCD Cameras for Astrophotography

- CCD cameras are optimized for Astrophotography. Typically this means:
  - High sensitivity CCD type sensors
  - Temperature controlled TEC sensor cooling systems to provide a controlled sensor temperature 30C to 60C below ambient temperature to achieve reduced and consistent noise levels
  - Provisions for binning of data
  - Provisions for reading small windows from the chip to speed data transfer
  - Provisions for filter wheels (on monochrome cameras)
- CCD cameras range in price from about $200 to about $20,000. The most common CCD cameras used by “dedicated” imagers are priced in the $3000 to $12,000 range.
- CCD sensor sizes commonly in use cover the same range as sensors in other digital cameras (from point and shoot to medium format) and pixel sizes range from about 4 microns to 16 microns.
- Monochrome cameras with filter wheels are the most popular due to the slightly greater resolution and sensitivity and due to the flexibility of using narrow bandwidth filters when desired.
- Many CCD cameras have built in provisions to assist in autoguiding.

CCD Cameras for Astrophotography

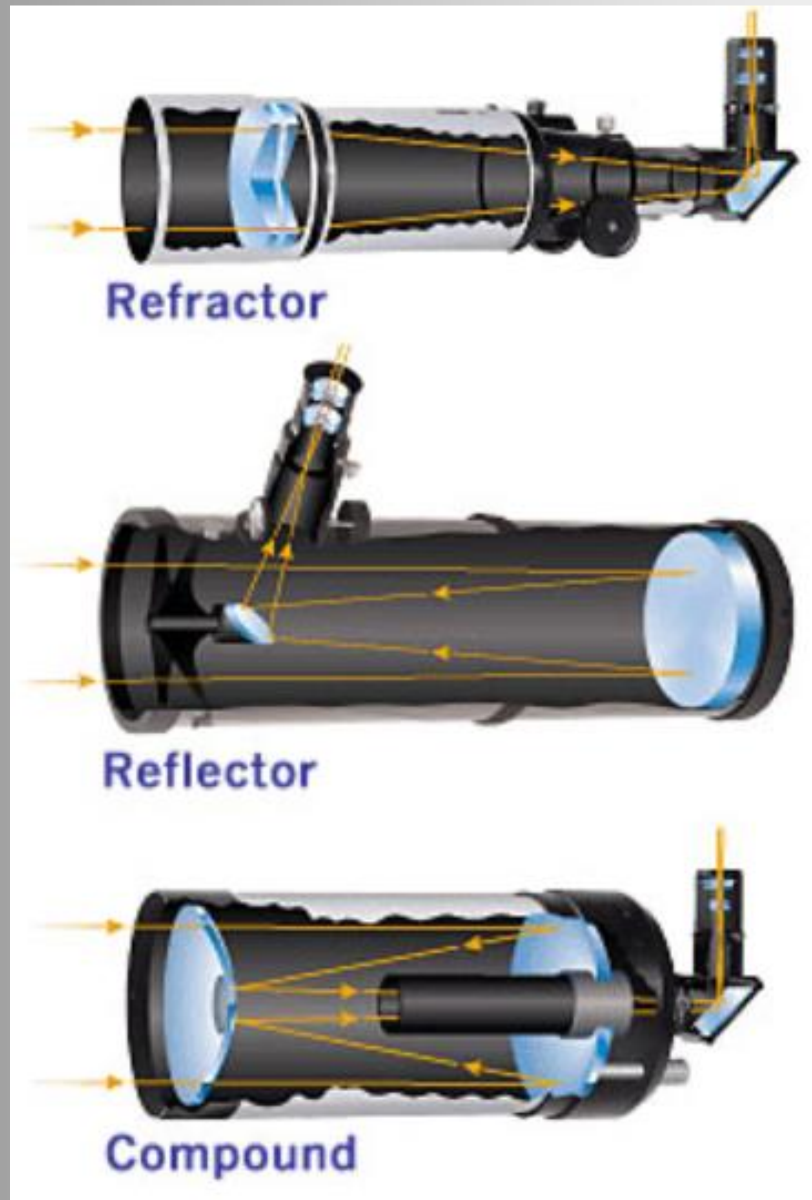
Two of the most popular current models ($4000 to $6000)

Both models are available with a choice of sensors

Optics for Imaging

- Camera lenses
- Spotting scopes
- Telescopes
  - Refractors
    - Much like simplified camera lenses
    - Fixed focal lengths ranging from about 300 mm to 1200 mm
    - Prices vary by optical quality. Top quality apochromatic refractors cost approximately $2000 (3” objective) to $10,000 (6” objective
  - Newtonians
    - Simple mirror configurations
    - Bulky and large and not as easy to use for photograpy
    - Best bang for the buck for visual observing
    - Large optics are available at reasonable prices (newtonians up to 25” mirror diameter are common at star parties)
  - Cassegrains (Compound)
    - Combine a large mirror with refractive elements to give large apertures in more compact packages
    - Excellent for long focal length observing or imaging
    - Common sizes range from 4” to 16” apertures with costs much below those of apochromatic refractors of similar aperture
  - Other

Optics Choices



Mounts for Imaging

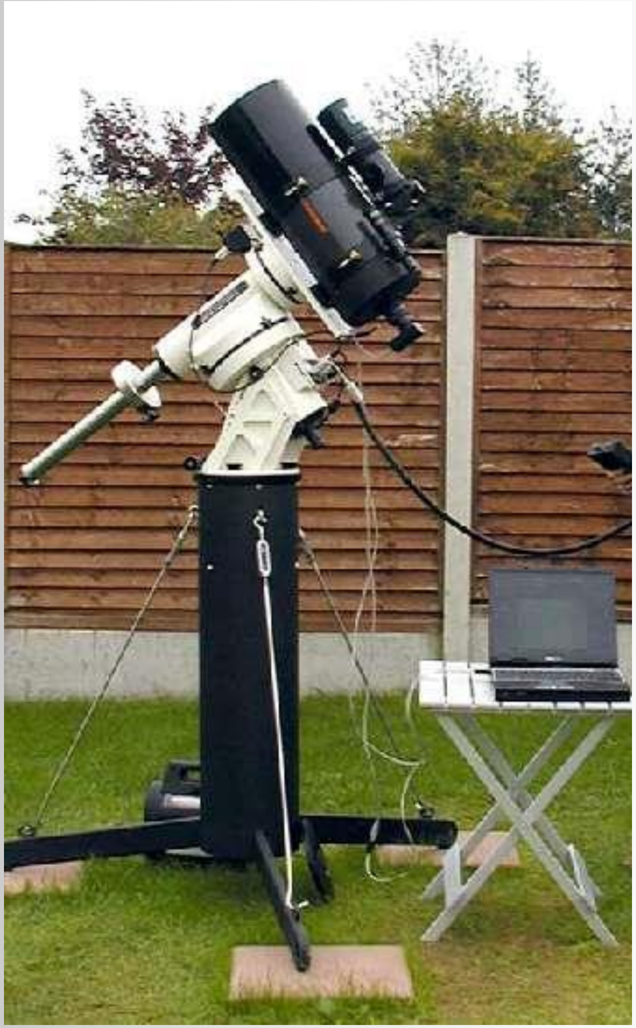
- A tracking mount is possibly the most critical component in deep sky imaging.
- Even with the best mounts, autoguiding is often required for long exposures with long focal length optics.
- Autoguiding is accomplished by means of a second imaging system (or a second sensor in the CCD camera) that takes frequent images (every few seconds) and monitors the position of one star on the frame. If the star has shifted even a fraction of a pixel from its initial position the software sends correction signals to the mount. Prior to digital cameras, a human provided this function by viewing through a guide scope attached to the main scope and sending corrections though the hand controller.
- Most modern tracking mounts provide for GoTo operation and can be controlled by either a hand controller or a computer.
- Requirements
  - Must be capable of carrying the load
  - Smooth tracking and easy to auto guide (low periodic error and low backlash)
  - Convenient to polar align
  - Convenient to use for imaging directly overhead
- Mount types
  - Fork mount (alt-az)
  - Fork mount (equatorial by means of a wedge)
  - GEM (German Equatorial Mount) the most common solution for imaging

Low cost (NOT)

Warning! The following slides may not be suitable for spouses, family members, or friends that are not fully dedicated to the astro imaging experience. They depict images and monetary factors that are potentially damaging to the general public.

Key Aspect of Mounts, Alt-Az vs. Equatorial

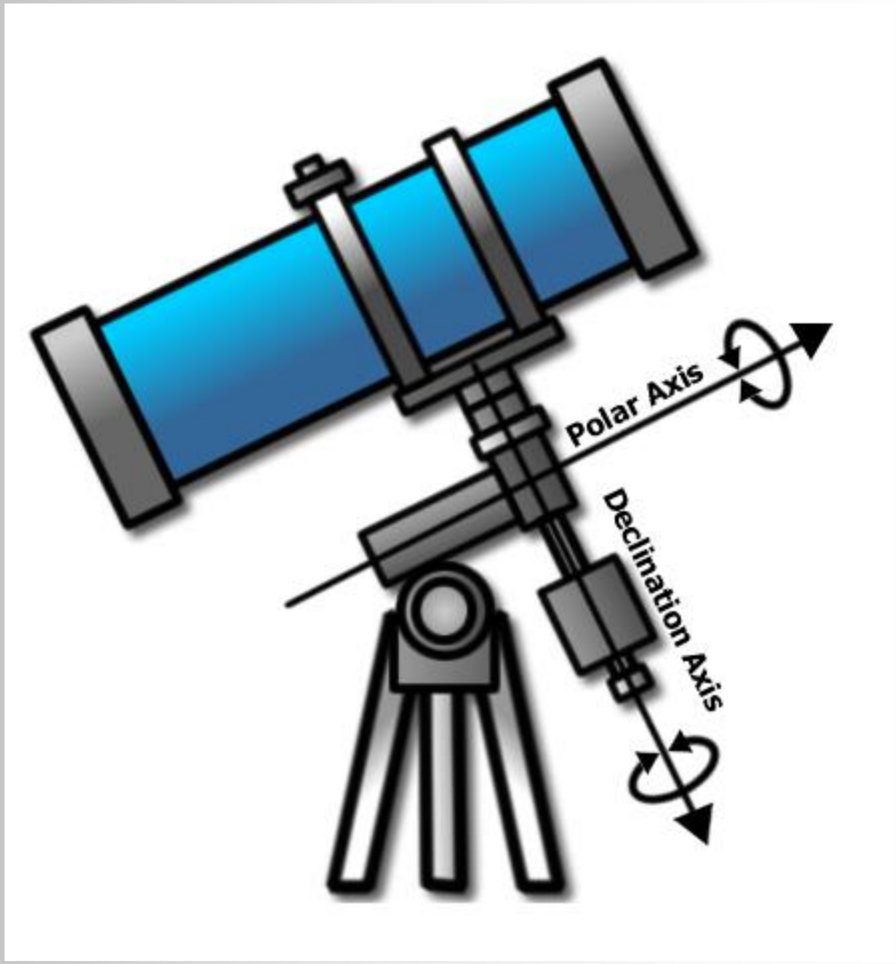
Altitude-Azimuth Mount



Equatorial Mount

Equatorial Mount Basics

- One axis (referred to as the Polar Axis) is oriented parallel to the earth's rotational axis, hence it is pointed toward an area of the sky near Polaris.
- This permits one motor to rotate the mount about this polar axis to offset the effect of the earth's rotation and prevent star trails.
- As long as the polar axis is correctly oriented, the telescope can be pointed in any direction and once pointed at the desired object, only the one motor is needed to keep the object aligned in the telescope and to prevent star trails.



Equatorial Mount

iOptron SkyTracker ($399) – A Simple,Low Cost Equatorial Mount Option for DSLRs

iOptron SkyTracker (Simple Equatorial Mount)

Celestron Advanced VX Equatorial Mount

- Typical entry level equatorial mount ($799)
- You probably paid that more than that for your Gitzo tripod and ball head!
- Suitable for observing or imaging with telescopes and/or camera gear weighing up to about 25 lbs
- Convenient GoTo operation from either the hand controller or a computer
- Adequate for imaging applications due to provisions for permanent periodic error correction and autoguiding

Another Example of a Low Cost Equatorial Mount

Meade LXD75 ~ $700 ~ 30 lbs capacity

Fork Mounts ~ $200 to $20,000 Depending on Size

(Better suited to imaging when mounted on a wedge to operate in equatorial mode and permit polar alignment)

Alt-Az Configuration

Equatorial Configuration

More GEM Mounts

Losmandy G11 Gemini

Up to 60 lbs capacity

One of the most popular mid-sized mounts

Good portable imaging mount

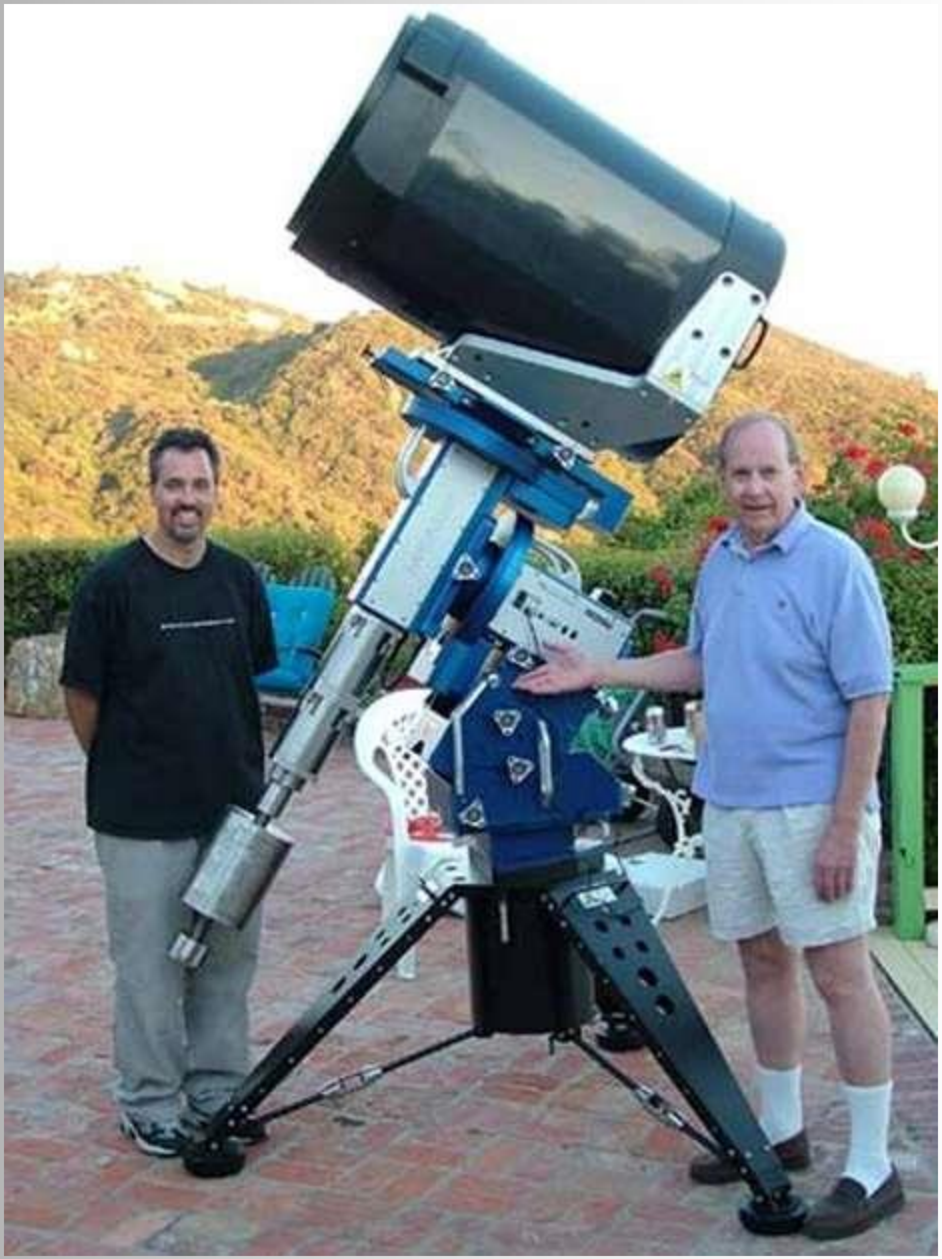
~ $3200

AP1200 ~$10,000

~ 130 lbs capacity

Meade MaxMount

~$20,000 ~ 200 lbs capacity



Mountain Instruments 1000

400 lb capacity ~$ (Don’t ask!)

Image Processing – Deep Sky Images

- The procedure is largely the same whether processing DSLR data or CCD data
- The majority of the steps in the process are best accomplished by the use of imaging software such as Maxim DL or ImagesPlus (but most imagers use additional software such as Photoshop for final tweaks)
  - Acquire multiple images of the subject in RAW or FITS format (for best dynamic range etc.)
  - Calibrate the images
    - Apply dark corrections (reduce noise due to dark current and hot pixels etc.)
    - Apply flat corrections (correct for vignetting and light path defects such as dust or water spots)
    - Apply bias correction (reduce read noise)
  - Align the images (typically the software can do multiple star alignments which can correct for minor translational, rotational, or scaling changes between images).
  - Statistically combine the images to improve the signal to noise ratio. This is not an additive process but rather a statistical combining that could be as simple as averaging or using the mean value at each pixel, but can incorporate more complex approaches.
  - If a color image is desired from multiple monochrome images, the above steps are conducted for each monochrome set (red, green, blue, luminance, Ha, etc.) then the combined monochrome images are color combined.
    - Align images
    - Select ratios to be used for each monochrome set
    - Color combine by RGB, LRGB or similar methods
  - Enhance the combined image
    - Levels, curves, digital data processing, etc. to expand the important portions of the histogram
    - Gradient removal, star size reduction, sharpening, additional noise reduction, etc.
    - Local treatment for spot removal, contrast adjustments etc.
  - Convert the image to an uncompressed TIFF image for any further processing in other software applications

Brief Processing Examples from ImagesPlus and Maxim DL

- Maxim DL Software
  - Maxim DL Camera Control
  - Maxim DL Focus
  - Maxim DL Guiding
  - Maxim DL Sequences
  - Maxim DL Calibration
  - Maxim DL Combining

- ImagesPlus Software
  - Camera Control
  - Image Acquisition
  - Batch Processing
  - Histogram and DDP
  - Other Processing steps
  - Conversion to Uncompressed TIFF

- Final Processing Tweaks Implemented in Your Favorite Programs (Photoshop, Lightroom, etc.)

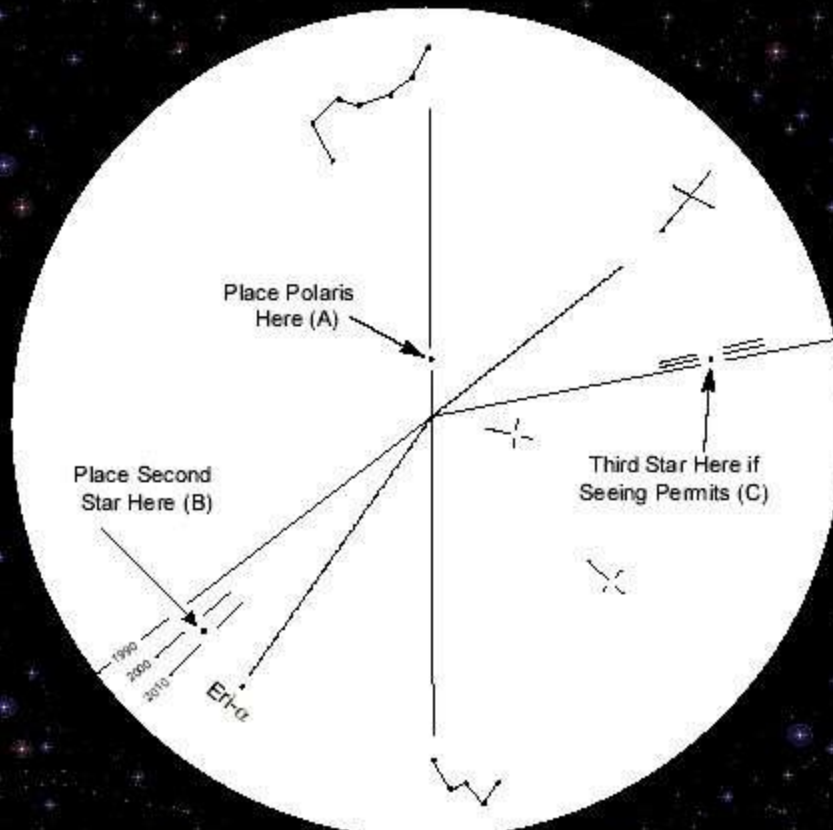
Getting Started

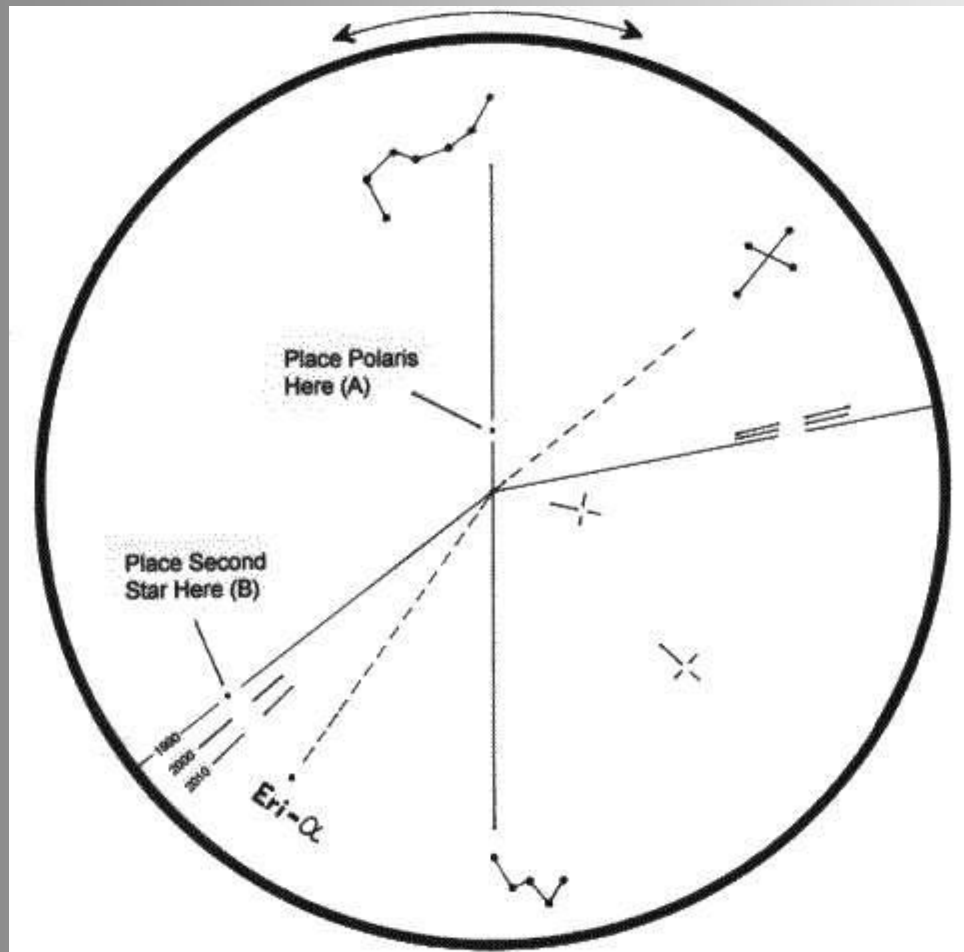
- Columbus Astronomical Society (CAS)
  - Meets at Perkins Observatory (Rt. 23, just South of Delaware) 2nd Saturday of each month at 8:00 pm
  - Participates in many of the Perkins programs that are open to the public on Friday and Saturday evenings
  - CAS members frequently set up a variety of telescopes on the Perkins front lawn on clear Friday and Saturday nights, a great way to become familiar with a variety of telescopes and the night sky.
  - CAS Imaging Sig (meets next at Perkins on Saturday Feb 15 at 1:00 pm)
- Sky and Telescope Magazine
- Manufacturers (with broad range of products)
  - Celestron
  - Meade
  - Orion
- Internet forums
- DSLR modifications for astro imaging (not a complete listing)
  - Hap Griffin (sells modified cameras or will modify your camera (~300)
  - Hutech (sells modified cameras complete)
  - Baader Planetarium (Germany)
- Software -- Too many options to list here. Useful astro imaging packages range from freeware such as Registax to low cost packages such as BackyardEOS, to complete astronomical imaging packages such as Maxim DL ($500) and ImagesPlus ($279).
- Hutville (see me about guest visits)

Questions and What's Next

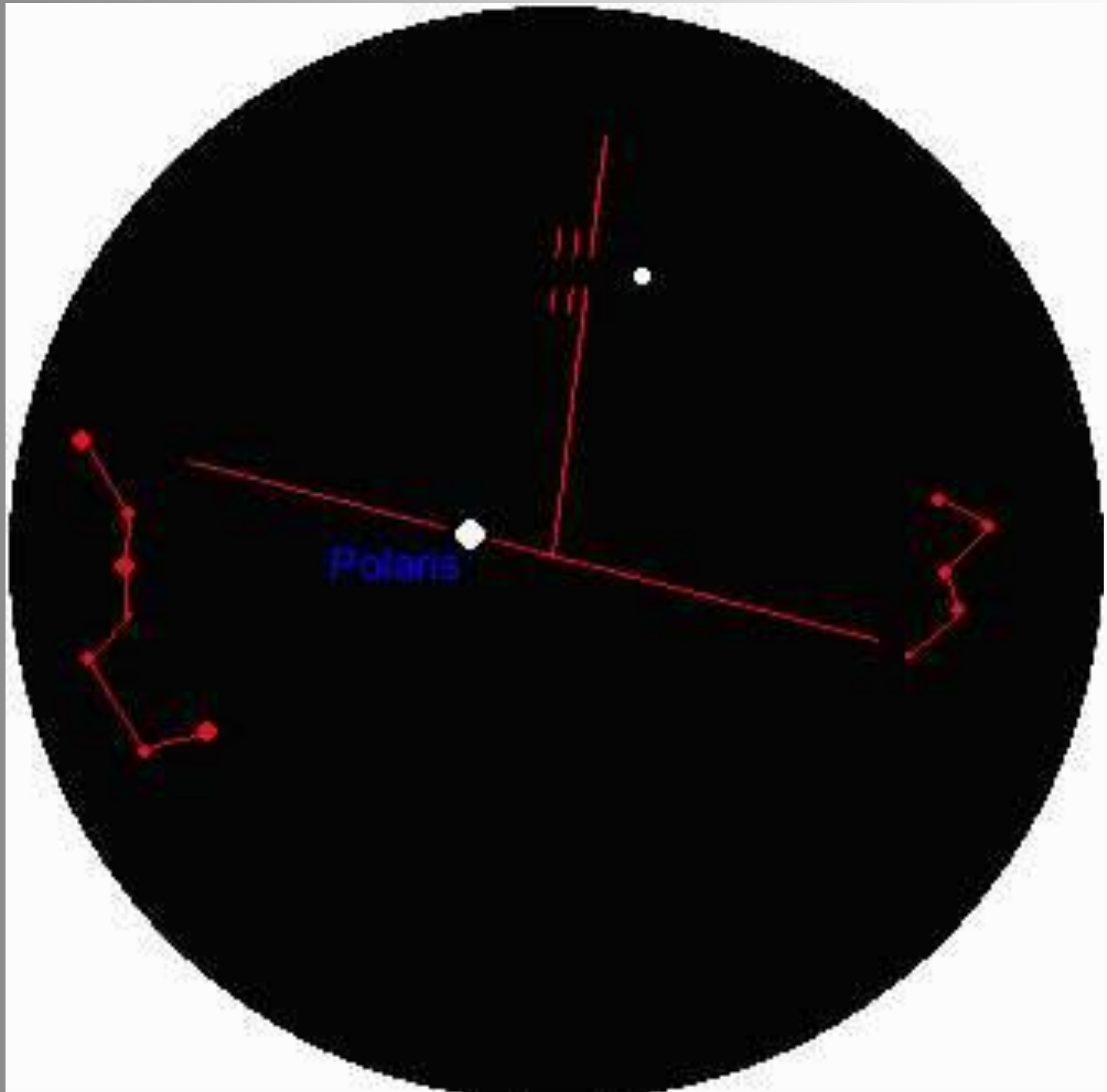
The Polar Alignment Scope

(how to use the G-8/11 Polar Alignment scope)





Place Polaris
Here (A)
Place Second
Star Here (B)
1990
2000
2010
Eri-α


Polaris

Basic Drift Alignment

- There are many options for drift alignment
- Some are computer assisted
- The following method is one of the most common, and only requires a reticle eyepiece

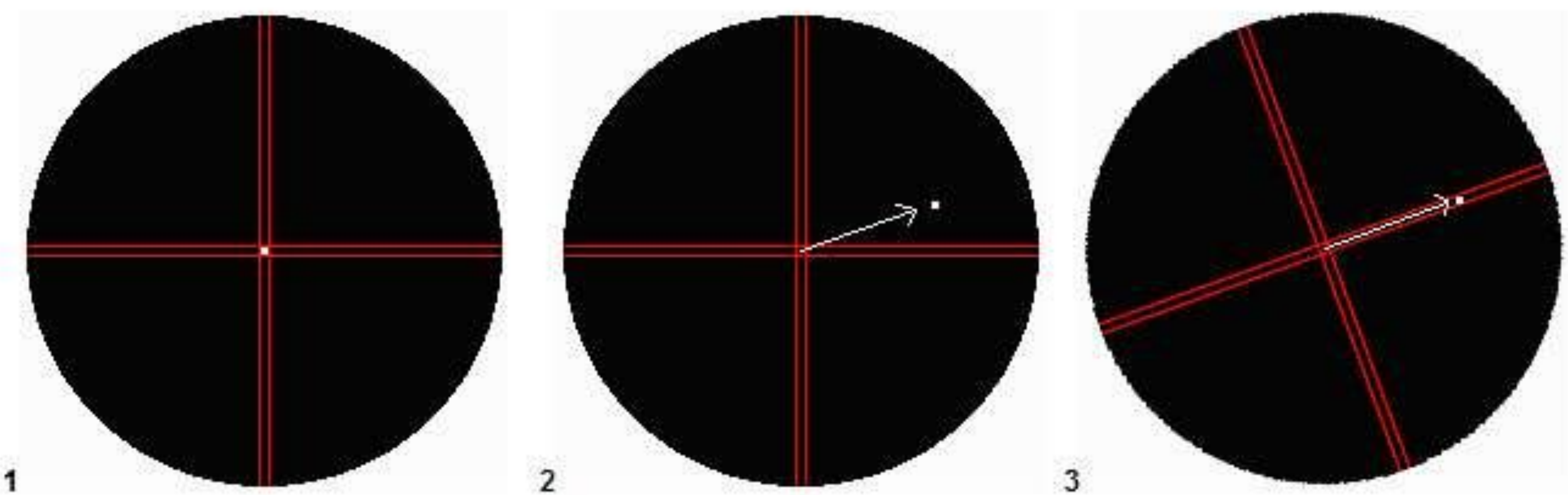
Azimuth Adjustment

- The drift alignment requires that you let the telescope track on two different stars in specific locations in the sky. Watching how the stars drift relative to the reticle in the crosshair eyepiece tells you how far the mount is offset from true celestial north and in which direction.

- Pick a star near the meridian, just north of the celestial equator (due south, between about 60°-70° above the horizon from the U.S.). Select a star that is reasonably bright but not too bright (about magnitude 3-4). Be sure that no other similar stars are in the field of view, as you do not want to get confused as to which star is which.

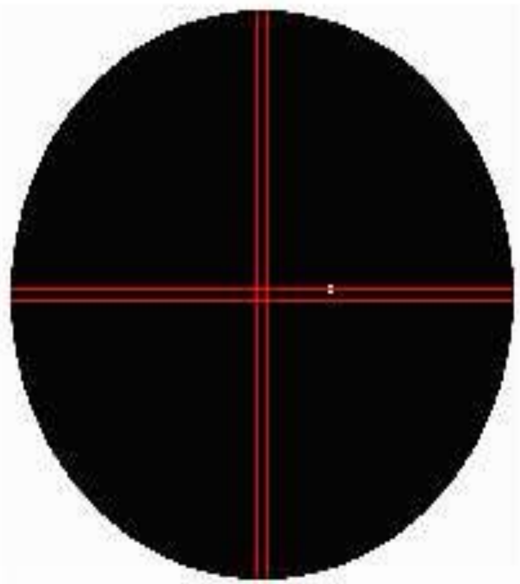
- Aim the telescope to this star. Rotate the diagonal until the eyepiece is oriented so that you are standing on the north side of the telescope when looking into the eyepiece. This step is not absolutely necessary but will make the following procedure easier.

- The crosshairs of the eyepiece must be aligned with the north-south and east-west directions. Center the star in the eyepiece. Use the mount's hand-controller to move the star east and west (roughly left and right) in the eyepiece. You should see that the star's motion is not perfectly parallel to the horizontal lines in the eyepiece. Rotate the eyepiece and check the east-west motion again. Repeat until the crosshairs are properly aligned.



Above: *Rotate the eyepiece so that the crosshairs are parallel to the east-west motion of the star in the telescope.*

- Once the crosshairs are oriented, place the star **on** one of the lines east-west (approximately horizontal) lines. In other words, the star image should be bisected by one of the horizontal lines as shown below. Do not place the star between the lines, as it will not provide enough accuracy for the following steps.



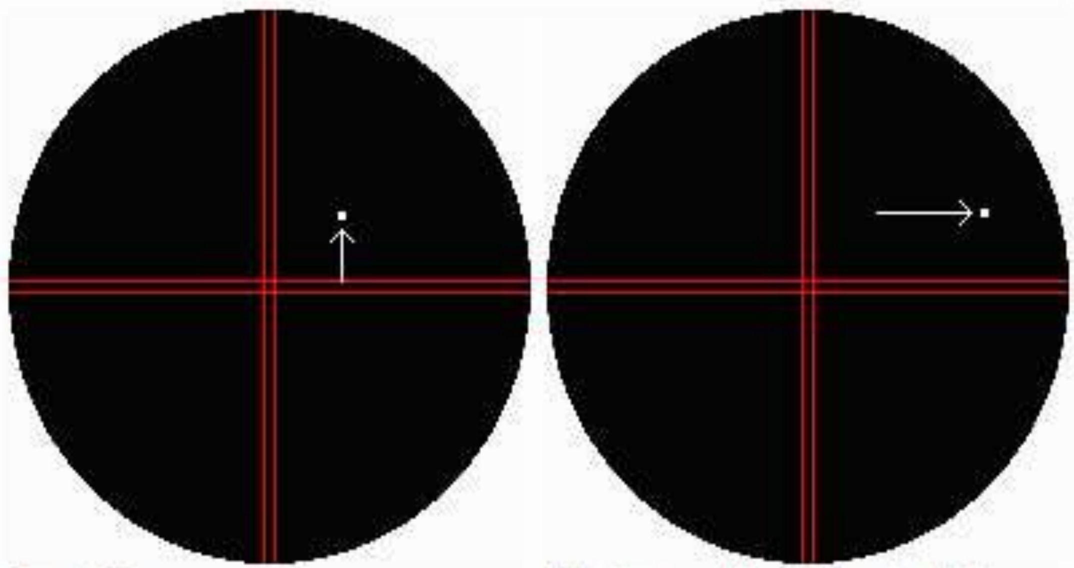
Above: *Place star on east-west line.*

- Let the telescope track for a minute or so. You will see the star begin to drift off of the line. It will drift either north (above the line) or south (below the line). Ignore any east-west (left-right) drift.

Newtonian telescope users must reverse the following directions

- If the star drifts **up**, use the mount's azimuth adjustment knobs to move the mount so that the star appears to move **right** in the field of view.

- If the star drifts **down**, use the mount's azimuth adjustment knobs to move the mount so that the star appears to move **left** in the field of view.



Star drifts up *Adjust mount to move star right*

- Use the hand-controller to move the star back onto the horizontal line.

- Let the star drift again. You should notice that it takes longer for the star to begin drifting off the line. Repeat the azimuth adjustments, placing the star back on the crosshair again when finished.

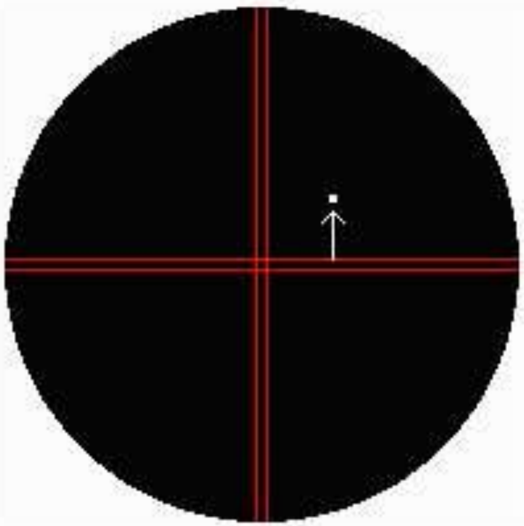
- Continue letting the star drift and making adjustments until the star takes about 5 minutes to drift off the line. Again, ignore any left-right motion. Once the star stays **bisected** by the line (not just close to the line) for 5 minutes without any drift, your mount is accurately aligned in azimuth. Now you just need to adjust the mount in altitude.

Altitude Adjustment

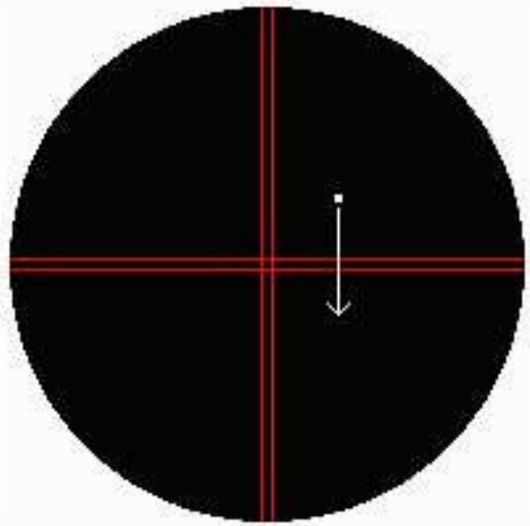
- Pick a second star in the east, about 20° above the horizon, near the same declination as your first star (near the celestial equator). In other words, move the telescope mostly in right ascension to select the second star. If there are any obstructions on your eastern horizon, it is possible to achieve an accurate alignment using a star up to about 50° above the horizon.
- If you do not have an unobstructed view to the east, a star in the west can be chosen. You must reverse the adjustments below, however, if you use a star in the west.
- Rotate the diagonal so that you are now standing on the south side of the telescope when looking in the eyepiece. Again, this just makes the adjustments easier.
- Orient the crosshairs again as you did above, so that the horizontal crosshairs are parallel to east-west motion and the vertical crosshairs are parallel to north-south motion.
- Place the star on one of the horizontal lines.
- Let the star drift. You should notice some drift after only a minute or so unless you initial rough alignment happened to be very good.

- If the star drifts **up**, use the mount's altitude adjustment knobs to move the mount so that the star appears to move **down** in the field of view.

- If the star drifts **down**, use the mount's altitude adjustment knobs to move the mount so that the star appears to move **up** in the field of view.



Star drifts up



Adjust mount to move star down

- Use the hand-controller to move the star back onto the horizontal line.

- Let the star drift again. You should notice that it takes longer for the star to begin drifting off the line. Repeat the altitude adjustments, placing the star back on the crosshair again when finished.

- Continue letting the star drift and making adjustments until the star takes about 5 minutes to drift off the line. Again, ignore any left-right motion. Once the star stays **bisected** by the line (not just close to the line) for 5 minutes without any drift, your mount is accurately polar aligned. You are ready to begin imaging the heavens!

Balancing The Mount and Telescope

Balancing a German-Equatorial-Mounted Telescope

It is very important to balance the ***telescope tube (declination axis) first!*** The most common balancing error is to reverse these steps. See the section at the bottom of this page for details why this procedure is critical.

1) Begin by rotating the telescope and counterweight bar so both are parallel to the ground, as shown below. Carefully release the clutch holding the optical tube (declination) axis in place and see if the telescope is front-heavy or rear-heavy.

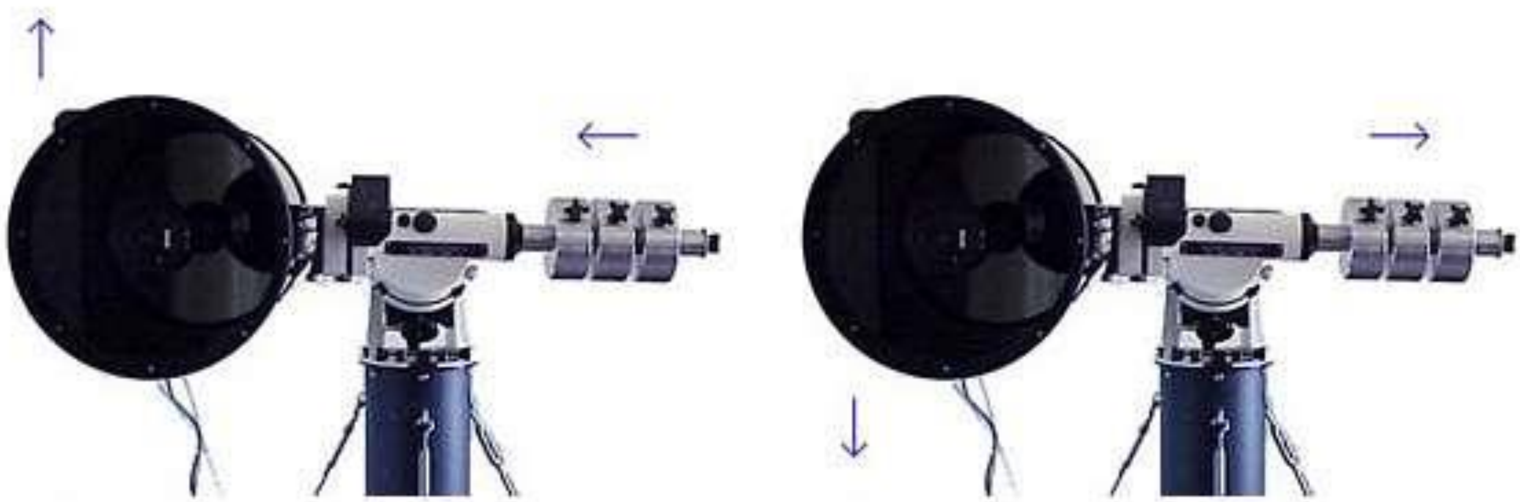
Above: *Push the telescope gently up and down to determine if it is front- or back-heavy*

2) Rotate the telescope so that it is directly above the mount and aimed north. The telescope can now be slid forward or backward to achieve proper balance.

Above: *If the telescope is front-heavy slide the tube rearward on the mount. If the scope is rear-heavy, slide the tube forward on the mount.*

Keep some extra weight on the EAST side, so that the drive gears are always loaded

3) Bring the telescope and counterweight bar back over into the horizontal position. Carefully release the clutch holding the counterweight bar (right ascension) axis and see if the setup is telescope- or counterweight-heavy.



Above: *Return the telescope to the horizontal position once balanced in declination. If the telescope is heavy toward the optical tube, slide the counterweight down the shaft away from the scope. If the telescope is heavy toward the counterweight, slide the weight up the shaft toward the scope.*