

## Constellation Astrophotography

with a film camera and including some digital camera notes

(FW Kleinhans - Physics - IUPUI)

- **Astrophotography** is relatively simple with modern films and cameras. With an exposure of just 10 to 30 seconds it is possible to photograph more stars than are visible under the best of conditions with the naked eye. Thus the familiar constellation patterns and the colors of the brightest stars are easily captured.
- **Film Cameras:** The best cameras are actually old, manual cameras (which require no battery for shutter operation, although they may well require a battery for light meter operation). However many modern cameras will also work fine. The key thing is to be able to take time exposures of at least 10 seconds.
  - On old cameras, time exposures are generally accomplished by setting the shutter on 'B', for bulb, and holding the shutter button down for the desired length of time. Of course, the camera needs to stay steady during this exposure. This is generally accomplished by placing the camera on a tripod and using what is called a 'cable release'. The cable release is a short, flexible cable which can be screwed into the shutter release and essentially extends the shutter button. By pressing the end of the flexible cable, the shutter can be fired without shaking the camera.
  - On a fancy, modern, camera with full adjustment capability, astrophotography is still easy. However your fancy camera requires a battery (\$5 to \$10) to operate the shutter. It will not mind keeping the shutter open for a few minutes. However on a cold (and hopefully dark night) an exposure of 30 minutes to several hours could severely drain the battery.
  - With an automatic, Point and Shoot camera, astrophotography may or may not be possible. Three things are necessary. First it must be possible to turn off the camera flash. Second, you need to be able to force the lens to focus at infinity (check the manual). Third, you have to see how long the shutter stays open under dark conditions. On my Point and Shoot, I tested this by taking the camera into a dark room and pressing the shutter button. About two seconds elapsed between the click of the shutter opening and the click of it closing. Not long enough. Try yours. Expensive Point and Shoot cameras may have some sort of time exposure setting.
  - Pentax K1000, Ricoh KR5, Vivitar 3800, and Phoenix P1 Single Lens Reflex Cameras: These are the cameras we have for class. The shutter is fully manual. The battery is only for the light meter and is not needed.
- **Digital Cameras:** Some modern point and shoot digital cameras have the necessary capabilities to take good constellation photos. These include:
  - Hi ISO setting, say 800.
  - Manual long exposure times, i.e. 15 seconds, along with dark frame subtraction.
  - The ability to force the focus to infinity.

If you have such a camera, by all means, consider using it for this constellation astrophotography project.

- **Film Camera and DSLR Lenses:** A standard 50 mm focal length camera lens is about perfect for constellation photography. Many Point and Shoot cameras of fixed focal length have a 35 mm focal length lens. This works fine too. If your camera has a zoom lens, start with the normal to wide angle setting. Telephoto lenses are not much use for constellation photography.
- The maximum lens aperture or lens speed is important. Most lenses are marked with aperture settings such as f 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22, and 32. The smaller the number, the more light the lens lets through (to the film). Each step represents a factor of two difference in exposure. Thus if you can obtain a nice star photo in 10 seconds at f2, it will take 20 seconds at f2.8. Three steps represent a factor of  $2 \times 2 \times 2 = 8$ , etc. Thus 10 seconds at f2 is the same as 80 seconds at f5.6.
- We want to let as much light through the lens as possible, so we want the lens opening to be as large as possible. In photo speak, this means using the smallest f number available. Our class cameras have a maximum aperture (smallest f #) of f1.4 to f2.0. Lens up to f4 should work okay. The bigger the f number the slower the lens and the longer the exposure it requires. Our lens go as slow as f16 to f22. If you have a Point and Shoot with a zoom lens, the maximum aperture is probably only f4 to f5.6. These will probably just barely work. Try and see.
- Lenses generally have some flaws when used 'wide open' at maximum aperture. Our lenses are of good quality and this will not be a problem for modest enlargements of the pictures. Astrophotographers with tracking platforms some times reduce their lens opening by one or two stops (say f2 to f2.8 or f4.0) and increase their exposure times in order to get higher quality star images around the edges of their pictures. For our pictures, we will use the lens wide open.
- Most lens exhibit vignetting when used wide open at their maximum aperture. This means your astrophotos will look brighter in the center and dimmer around the edges. This effect is most noticeable when using the 50 mm f1.4 lenses wide open at f1.4
- **Digital Camera Lenses:** Digital 'Point and Shoot' cameras generally all have zoom lenses with a wide angle setting of 35 to 38 mm (equivalent 35 mm film camera) focal length. At the wide angle setting these lenses are generally about f2.8. Use these lenses at f2.8 at the wide angle setting.
- **Film:** Modern films work miracles on the stars. I recommend Kodak Max Versatility Plus 800 speed Color Negative (print) film because of its ready availability and good colors, especially red, on astronomical objects. More generally, for our purposes, we need a minimum film speed of 400. I recommend 800 to 1600 speed film for most of our class projects. My demonstration pictures were shot on Fuji Color 1600 speed film. For constellation photography, the brand is unimportant, however ...
- **Red Sensitivity:** Many nebulas in the sky, e.g. the Orion Nebula or the North American Nebula, have a deep red color (H $\alpha$  light). Most films are relatively poor at capturing deep red. If you want to capture red nebula (entirely possible) in you class photos, the film brand/type is very important. Currently (10-2-06) I recommend Kodak Max Versatility Plus 800 speed film based on my recent tests. This is a constantly moving target. Films are forever changing and the manufacturers (understandably) give no consideration to the astrophotography characteristics of their consumer films. Check with me for the latest word.
- High speed films (800 and faster) are generally considered at risk in airport X-Ray machines. Hand carry your high speed film through security; but you have no assurance that this will be permitted, even if the law gives you the right.

- **Digital Camera Speed:** I recommend a digital camera ISO speed setting of 800. Turn off the LCD screen to reduce heat and noise in your pictures.
- **Record Keeping:** Keep a written log of your exposures. You will never remember after your fifth picture. Personally, I use a small portable tape recorder in the field for convenience and transcribe the data to paper. Pictures (and negatives) are most conveniently kept in photo sheets which fit in a regular 3 ring binder.
- **Exposure time:** With a regular 50 mm lens and especially for a telephoto lens, the key factor, which limits exposure time (for unblurred stars), is the motion of the stars resulting from the spin of the Earth. The following table is an approximate guide for 35 mm film cameras. The actual star motion depends on the location of the star in the sky; less for stars near Polaris, more for stars distant from Polaris. For APS cameras, reduce the times by about 1/3. As can be readily seen, photographing the stars using a telephoto lens on a fixed tripod is a losing proposition; ... try it anyway if you have one. For digital cameras, use 10 to 15 sec at the wide angle setting. If your digital camera has a 'dark frame' capability, use it. I.e. after it takes a 15 second picture of the stars, it takes another 15 second picture with the shutter CLOSED and subtracts the two, to reduce noise.

| Lens Focal Length<br>(mm)            | Exposure Time |           |         |
|--------------------------------------|---------------|-----------|---------|
|                                      | Good Images   | Elongated | Trailed |
| 35 mm (wide angle)                   | 30 sec        | 45 sec    | 180 sec |
| 50 (normal)                          | 20            | 30        | 120     |
| 85 (telephoto)                       | 12            | 20        | 75      |
| 100                                  | 10            | 15        | 60      |
| 135                                  | 8             | 11        | 45      |
| 200                                  | 5             | 7.5       | 30      |
| Digital Camera at wide angle setting | 10            | 15        | 25      |

If everything is set up to give a good exposure in 10 to 30 seconds, how do you take a ten minute exposure showing star trails? With fast film, a long exposure will pick up the light pollution in the sky and ruin the exposure. To photograph star trails for tens of minutes (or for hours) the lens needs to be stopped down. Lens openings of f5.6 to f11 should work well for long exposure star trails. (Of course you can use slower film, but you want to avoid using several different types of film for your work.). I recommend 15 minutes at f8 on 800 speed film. If you have a digital camera, tough luck. Star trails are possible if you are proficient with image manipulation programs and are willing to 'glue' multiple exposures together.

- **Misc. Details (Film):** Loading and unloading the camera: To open our cameras, lift the knob on the left, top side of the camera (with the lens pointing away from you.) Be careful not to stick your finger through the focal plane shutter in the back of the camera. After loading the film, you will have to advance the film a few frames to get to film that has not been exposed to light. When finished with your astrophotographs you have to rewind the film. Don't open your camera yet! Press the button on the bottom of the camera in (it should stay in); then turn the rewind knob on the top left of the camera in a clock wise direction until the film is fully wound into the cassette. Now you can open the camera and remove the film.
- It is always smart to put a 'regular' photo at the beginning and end of a series of astrophotographs. This helps the lab figure out where the frame lines are when they cut the film. Occasionally a lab will cut all your pictures through the middle. If you are paranoid about this, you can have the lab return your photos uncut. I have not had any problem with this in recent years. As long as a little sky fog shows up on the pictures, the frame lines will be clear (for cutting).

Thus your astrophotography roll needs a regular photo (your front yard, kitchen, living room, what ever) at the beginning. No problem if you have an automatic camera; just shoot one. If you are shooting with our class camera, you will have to guess the exposure. No problem. Print film is tremendously forgiving. If you are taking an outside photo, just stop your lens down to f16, set the shutter speed on 1/250 sec, and shoot. Often it will be the case that you don't want to put your special astrophotography film in the camera until you are sure you are going to use it; like 9:30 PM and you just noticed the sky is crystal clear. So you will need to take a shot of an indoor scene for that first regular photo. A well lit room in the average home can be photographed with 800 speed film using a lens setting of f4 and a shutter speed of 1/30 sec. In any case, never load your high speed film into the camera in direct sun light. You don't want light streaks on those hard won exposures.

- **Dew and Cold:** Dew is always a problem in the Midwest. For our projects, just keep your camera warm until you are ready to take photos and you should be okay. For long sessions, a lens hood slows down dew formation. Nitpickers take 12 volt battery packs, lens heaters, and portable hair dryers with them.

Cold makes film more brittle. Wind your film slowly on really cold nights. Don't rewind the roll till you are inside and the camera has warmed up.

- **Processing:** Any one hour photo lab will do fine for developing your film. I prefer ones which do not put fingerprints, spots, and scratches all over my negatives! The automatic machine prints from your negatives may or may not come out well. Sometimes I get good results; sometimes not. If the print is too dark, you will have a nice black sky, but the stars will barely show. If the print is too light, it looks esthetically unpleasing. On balance most prints are best with a medium to dark gray sky. However, the most stars are generally visible with a light gray background and if your star images are faint, this is the best you can do. If you give the lab an example print (perhaps a picture cut from an amateur astronomy magazine), they can generally do much better than a bad machine print. If you get serious about this, the only solution is to ask the lab to print a series of 4 or so prints using a range of settings. Only then will you get a really good feel for what your negative is capable of. I have first pass machine prints which look awful and final custom prints which look fabulous, all from the same negative.

Generally it's a good idea to tell the lab to print all your pictures no matter what. Of course if you didn't use the entire roll of film, tell them how many shots are on the roll. Some labs put frame numbers on the back of the prints. Some do not. When you get your photos back, carefully match up the pictures with the frame numbers (printed underneath the negative and

visible with a magnifying glass) and write the frame number on the back of the prints. If you mix the prints up in the excitement of looking at them, you may never figure out which print came from which negative!! An 8 to 10 X magnifier is good for examining negatives and prints.

- **Digital pictures** can be printed on any old color printer you have, or taken to the camera store for printing on photo paper.
- **Viewing and focusing: Don't forget to set your lens on infinity!** You may have trouble seeing the stars through your viewfinder. With a regular lens, just wing it; guess and point.
  - **Digital Cameras:**
  - **Viewing:** You will surely not be able to see any stars on the LCD screen. You might see some dimly illuminated foreground objects. It is best to leave the LCD screen off, if possible, for astrophotography as this reduces noise in the CCD (by allowing the camera electronics to run cooler). It is also unlikely that you will be able to see any stars through the optical viewfinder, if your camera has one. You just have to eyeball the camera direction and shoot. With your camera in the wide angle setting, this should work fine.
  - **Focusing:** Somehow you will have to force your camera to focus on infinity. Check the manual. It sure will not be able to auto focus on the stars. Some cameras default to infinity on focus failure, fine. Some cameras have a manual setting to put the lens at infinity focus. And many cameras have a 'Distant Scene' setting which should work. Try until you get something that works. That is the beauty of the instant feedback of digital photography.

### **Subjects:**

- Most of the above has been directed at photographing constellations. It would also apply to photographing comets such as we have had in the past few years. Other things to try:
  - Northern lights (aurora borealis): General instructions as above. Try exposures of 10 sec to 2 minutes with your lens wide open. But of course, there are only a few unpredictable nights a year when the aurora is visible from Indianapolis.
  - Meteor showers (e.g. the Perseids in August): A 50 normal mm lens works, but a 35 or wider wide angle lens would be better. Put the camera on a tripod, point it toward where you are seeing meteors, and try 5 minute exposures at f4 on fast film. You will probably have to take 10 to 20 pictures to get one or two nice meteors.
  - Solar eclipses: Read the special info on photography on the eclipse Web sites.
  - Moon: Unless you have a monster telephoto lens you will not get much detail on the moon. Very attractive shots can be obtained by including an interesting foreground. The same goes for shots of planets in the sky.

## Constellation Astrophotography Notebook

(see example I have)

- Put your project work in a notebook or bound folder. Include a cover page with name, course, date, and contents list.
- Include a page indicating equipment and film used and approximate locations where the pictures were taken.
- Include your original negatives (or slides). (I will return them after grading).
- If doing work with your own digital camera, I will need a CD with ALL the pictures from your photo session, both good and bad. Also include the normal before and after shots, just as for the film work.
- Finally, show prints of your work with full descriptive detail and a chart showing the region of sky photographed, as outlined below.

### Constellation Astrophotography

- Photograph two of the following constellations (Big or Little Dipper, Orion (Hunter), Leo (Lion), Taurus (Bull), Canis Major (Big Dog), Gemini (Twins), Bootes (Herdsman), Cassiopeia (the W), Orion is a beautiful constellation and especially good choice because of the pretty red Orion Nebula. Reproduce or hand draw a simple star chart to the same scale and orientation as the photographs and name the brightest stars. On the chart connect together the bright stars in the shape of the constellation if these lines do not already exist on the chart..
- Photograph the North Star (Polaris) and the region around the pole, showing star trails (recommended: 15 minute exposure @ f8).
- Photograph one or more constellations of your choice and include a star chart (as above).
- Take the above photographs from a moderately dark location. If you live in a brightly-lit area of the city, you may want to try a few photos from 'home' for comparison.
- Include data<sup>+</sup> on the same double page as each photo giving full particulars, including:
  - Shooting Location & Object Photographed
  - Camera
  - Lens setting
  - Exposure time
  - Film
  - Sky conditions (atmospheric clarity, light pollution, presence of moon, etc)
  - Date
  - Photographs should be 4" x 6" or larger (glossy is better). (Size does not affect your grade. Size only reflects the state of your pocket book and amount of blank wall space you have.)

Optional:

- Take an 'artistic' photo of the moon with an interesting foreground.
- Try to get a photo of the planets Venus, Jupiter, Mars, or Saturn. With good timing a photo of Venus in the early morning or evening with twilight and colors lighting up the sky would be pretty.
- Figure out the limiting magnitude of (some) of your constellation photographs. For this, you need a good star chart.
- Experiment with telephoto or wide angle lenses..

<sup>+</sup> There are lots of schemes for keeping descriptive data. For a personal notebook, I prefer data on the back of each print, so there is no way print and data can get separated. However, be careful what type of pen you use. A ballpoint pen will press through the print and ruin it. A fast drying felt tip pen with ink which does not penetrate the print works well. I use this for my 4"x6" catalog prints. I don't recommend writing on the back of large prints for framing. Eventually the writing may show through. For our class work we will need to write the data into our notebooks where it can be easily read.

# Check List - Film Cameras

(fwk iupui 9-27-04)

- **Load the film into the camera:**
  - (Do not do this in direct sunlight.)
  - Lift the rewind knob on the top left of the camera until the camera back pops open.
  - Put the film cassette on the left side and pull the film across to the take up spool on the right.
  - Thread the film into the slot on the right hand take up spool and wind about an inch of film onto it. If the wind knob stops, fire the shutter.
  - Make sure the film is aligned between the film rails, then close the camera back until it latches.
  - To get fresh film out of the cassette and into the camera, wind the film and fire the shutter, repeat. Leave the lens cap on so you don't end up paying for prints of your shoes!
  - Is the film advancing? If you are a worry wort, test proper film loading and film advance as follows:
    - Gently wind the rewind knob clockwise until you meet resistance.
    - Now when you wind the film, the rewind knob should turn counter clockwise as the film comes off the cassette spool.
- **Shoot a normal picture to mark the beginning of the roll:**
  - Outside in sunlite: shoot at f16 and 1/250 sec
  - Inside a brightly lit room at nite (e.g. kitchen): shoot at f4 and 1/30 sec
  - Inside your car using the dome lite: shoot wide open at 1/15 sec
- **Go to a dark place with many stars.**
  - Set up tripod.
  - Remove lens cap and securely attach camera to tripod.
  - Attach cable release by screwing into shutter button. If you have one of the fancy auto locking cable releases, make sure the lock ring is unscrewed.
  - Line up the camera with your target. This is hard. The camera will be low. You will be on your knees in the mud in a field. Take something to kneel on. The stars are hard to see through the viewfinder. You may have to aim by the seat of your pants.
- **Check Camera Settings:**
  - Set lens to f1.7 to f2.0 If you have a fast f1.4 lens you can use it at f1.4 with some increase in distortion and vignetting.
  - Camera lens focused to infinity ( $\infty$ ).
  - Shutter wound.
  - Shutter speed set to B.
  - Check lens for dew.
- **Fire shutter with cable release:**
  - Count off the seconds or use your watch. Twenty seconds is about best for constellations.
  - Release shutter by pressing on edge of locking ring (or unscrewing lock on old fashion cable release). Make sure you hear the loud noise of the shutter closing. If you don't, it means you did not have your shutter speed set to B.
  - Repeat process a few times, perhaps trying a few at 10 and 30 seconds exposure.
- **Find new constellation target and repeat process. Watch out for dew.**
- **When finished with star photos, put a normal shot at the end; see above.**
- **Check the frame counter to see how many shots you have.** Useful to be able to tell the film processor.

- **Rewind film:**
  - Press the small button on the bottom of the camera. It should click and stay in!
  - Rewind the film by turning the rewind knob clockwise. If it is hard to turn, it mean you screwed up the previous step; try again or get help. If you continue, you will rip the film, filling the camera with film fragments and cause me to get my mad dogs after you.
  - Keep rewinding the film until you hear the film pop off the take up spool and go completely into the film cassette. There is no harm in giving a few extra turns of the knob to be sure.
  - Definitely do not leave any film sticking out of the cassette. If you do you will just use the film over and ruin it with double exposures. So when you open the camera, make sure the film is fully rewound and if not, turn the cassette knob by hand until it is.
- **Now it is safe to open the camera:**
  - Pull up on the rewind knob, open camera, remove film.
  - Store film in dark place. Do not put it on your window sill in bright sun.
- **Process film:**
  - Your favorite regular place is just fine. The drug store, grocery store, multi store, camera store, wherever.
  - Write a note to include with the film.
  - "Please note: These are astrophotographs, i.e. pictures of the constellations. There is one regular picture at the beginning and end of the roll. In total there are XX pictures. Please print all the pictures. Automatic machine mode is just fine for the constellation photos."
  - I like the one hour processors where I can explain my needs to the actual technician who will do the work. I have generally found them to be friendly and sympathetic to my needs. Show them your pictures afterward and tell them what constellations you have captured.
- **IMMEDIATELY:**
  - Number your pictures from first to last. Once they get mixed up you will never figure out what is what.