

A step-by-step approach to Astroimaging: The steps required to take this image =>



- 1. Equipment Selection
- Camera
- Telescope
- Mount
- Computer & Software

2. Gathering Data

- Equipment Setup
- Lights, Darks, Flat Lights, Flat Darks, Bias

3. Processing Image

- Align and Stack
- Post Processing

4. References







* Not endorsing any type of equipment or configuration

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1. Equipment Selection - Camera



Options -





Dedicated Astroimaging Camera?

- Best results
- Expensive
- Most difficult

Planetary Camera?

- Not a planet
- Not optimized for Nebulae

DSLR? Digital Single Lens Reflex

- Easier to use
- Lots of support
- Lower cost
- Acceptable results
- Long exposures





Camera: Unmodified Canon 300D
Telescope: Celestron 80ED Refractor
Mount: Celestron ASGT

<u>10</u>x7min

The Holland Observato

E Lake Tano

NGC6992: The Waterfall Nebula (Super Nova Remnant)

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Remnant Waterfall A

12x5min

NGC7000: The North American Nebula

Lake Tahoe 7/13/09



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IC410: The Tadpole Nebula

Required Accessories:

- 1. T-Mount Adapter
- In place of lens
- Allows connection to telescope





\$15 (Agena Astro Products)

2. AC Adapter

- Battery produces heat
- Batteries die at inopportune times
- Battery life less in cold weather
- Difficult to change without moving scope

Example: ACK-E5 eBay: approx. \$16



Required Accessories:

- 3. Cabling (minimize)
- USB Exposure control & image transfer
 o Long to allow movement of telescope
- 4. Viewfinder Cover
- Prevents stray light from entering camera body
- Note Not used on this picture







Light Pollution from Imaging Site

Object to right =====→

Located in front yard of imaging site





Without Skyglow Filter





With Skyglow Filter

Can significantly help – example 4 minute exposures









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- Stays in camera
- Blocks broad band light pollution

1. Equipment Selection - Telescope

First parameter: Focal Length (FL) which determines field of view (FOV)

If FOV too wide (short FL):



If FOV too narrow (long FL):





How to fit target within image –

 Field of View: the angle subtended by an image sensor's horizontal and vertical dimensions

• Example: Canon APS-C sensor measures 22.2mm x 14.8mm. With a 1000mm fl telescope has a horizontal field of view of 1.27°, and a vertical field of view of .85°.

Second parameter: Aperture which determines light gathering and resolution Note – focal ratio / f-stop [= FL / Aperture] determines exposure time Trade off – Bigger is better, B-U-T: cost, *weight*, ease of use....





24" Planewave Instruments I wish, I wish.... \$50,000 8" (200mm) Newtonian Easy to use Low cost 1000mm FL, f/5

Major short coming of Newtonian telescope: Coma

In general, telescopes perform better on axis (middle) than off axis (edges).



DSLR with T-Thread Adapter and Coma Corrector

.



Next issue: Focus



Slide courtesy of UT NASA_Focuser Team

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8" Newtonian with Feathertouch Crayford Focuser



Progress check -

- 1. Equipment Selection
- Camera
 - ✓ Canon DSLR
 - ✓ T-Mount Adapter
 - ✓ AC Adapter
 - ✓ Long USB Cable
 - ✓ Viewfinder Cover
 - ✓ Astronomik CLS Light Pollution Filter
- Telescope
 - ✓ 8" Newtonian, 1000mm FL, f/5
 - ✓ Coma Corrector
 - ✓ Good Focuser

1. Equipment Selection – Mount

Mount Requirements:

- 1. Support telescope
- 2. Track sky accurately



Losmandy G-11 w/ polar align scope

How to calculate image scale / resolution:



- Problem: Image pixel size corresponds to approx. 1 arc second (1") of angle
- It is difficult to get a mechanical telescope mount to track accurately for long exposure pictures within around 1" of accuracy. Otherwise, pixels are smeared due to tracking errors. Good optics are of no use with a bad mount.

Image Scale: the angle subtended by one pixel

• Example: a 5.2um pixel (Canon 450D) with a 1000mm fl telescope has an image scale of 1.07".

1. Equipment Selection – Mount (cont'd)

Even the best mounts still have some errors, e.g. periodic error -



2. Send corrections to mount

Guide Camera



1. Equipment Selection – Computer & Software

Programs Needed:

- 1. Mount Control: Guiding PHD Guiding
- 2. Camera Control: Backyard EOS
- 3. Image Calibration: Deep Sky Stacker
- 4. Post Processing: Photoshop

Computer Requirements: 1. USB Connections (3) a) Imaging Camera, b) Guide Camera c) Mount 2. Sufficient Speed & Memory **Deep Sky Stacker** 3. Lots of Hard Drive Space Each image: 14MBytes Final: 80x14MB = 1.12GB3. Ability to Make Screen Red Rubylith: Scope Stuff

*** Will be demonstrated in next section =>

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Progress check -

1. Equipment Selection

- Camera
 - ✓ Canon DSLR
 - ✓ T-Mount Adapter
 - ✓ AC Adapter
 - ✓ Long USB Cable
 - ✓ Viewfinder Cover
 - Astronomik CLS
 Light Pollution Filter
- Telescope
 - ✓ 8" Newtonian, 1000mm FL, f/5
 - ✓ Coma Corrector
 - ✓ Good Focuser

Mount

- ✓ Losmandy G-11 German
 Equatorial Mount
- ✓ Polar Alignment Scope
- ✓ GPUSB USB to Autoguide Input Adapter
- ✓ Guide Scope, Guide Camera
- Computer & Software
 - ✓ Laptop, USB ports, Large Disc
 - ✓ Rubylith Red Screen Cover
 - ✓ Software: PHD Guiding, Backyard EOS, Deep Sky Stacker, Photoshop



2. Gathering Data – Equipment Setup (cont'd)

Nighttime Setup:

- Polar Alignment Options:
 - North Celestial Pole Polar Alignment Scope
 - Quick, easy. Good enough for many targets
 - Polar Alignment Software in Hand Controller
 - Declination Drift
 - More difficult, takes time. Best method
- GoTo Setup (with eyepiece, then remount camera)
 - User will center 2 or more bright stars allowing scope computer to create an accurate map of the sky (typically use 6 or 7 stars).
 - Afterwards, targets can be entered into scope computer and scope will slew to them.
 - Some scopes have 'Accurate GoTo' features that aid in finding faint objects
- Dew
 - Dew can form on scope, camera, filters, etc.
 - Just extending the length of the end of the scope will combat dew.
 - Raising optics above dew point prevents dew from forming (heater).
- Stray Light
 - You will need to address any sources of stray light (same dew extensions help).









2. Gathering Data – Equipment Setup (cont'd)

- There are many methods to obtain focus:
 - Hartman Mask, Measuring the Point Spread Function, Visual, Bahtinov Mask
 - Recommend Bahtinov Mask **

– Can make your own





Focus

http://astrojargon.net/MaskGen.aspx?AspxAutoDetectCookieSupport=1

In Focus

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2. Gathering Data – Equipment Setup (cont'd)

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Focus

Another method – Measuring Point Spread Function: Full Width Half Max – minimum Standard Deviation – maximum











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2. Gathering Data – Lights, Darks, Flat Lights, Flat Darks, Bias

- Finding Your Target
 - At Least Three Options
 - GoTo Scope select from list
 - Accurate GoTo function
 - Computer Control
 - Via scope RS-232 interface
 - ASCOM drivers
 - Planetarium Programs
 - » The Sky
 - » Cartes du Ciel
 - Star Hopping
 - Star charts
 - Note: Best results when target near Zenith due to atmosphere



2. Gathering Data – Lights, Darks, Flat Lights, Flat Darks, Bias (cont'd)



- 1. Getting Close –
- Precise Go-To, Adding nearby star to calibration stars
- 2. Fine Tune -
- Take short test images, compare to star charts, fine movements

2. Gathering Data – Lights, Darks, Flat Lights, Flat Darks, Bias (cont'd)

In addition to images of targets, will need calibration frames

- Build up of noise due to heat / thermal energy
- Imperfections in optical system and less than clean optics

Definitions:

.

Lights – Images of celestial object

Darks – Thermal noise (electron leakage), same duration, same temperature

Flat Lights – Evenly illuminated image showing imperfections in optics

Flat Darks – Thermal noise image, same duration, same temperature as Flat Lights

Bias – Image of shortest duration which provides offset from zero

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Lights: 40x5min Darks: 10x5min

Flat Lights: 10x1/250s Flat Darks: 10x1/250s Bias: 10x1/4000s All at ISO 400



With dark frame subtraction only, Imperfections remain (dust donuts, vignetting)



 $(42 \times 1 \text{ minute lights}) - (10 \times 1 \text{ minute dark}),$ Then aligned and stacked

1 dark frame (1 min)

Thermal

present

in both

light &

frames

dark

noise

 $(42 \times 1 \text{ minute lights}) - (10 \times 1 \text{ minute dark}),$ Then aligned and stacked



Flat field image

Multiple images are combined to improve the signal -

Why does aligning and stacking images increase the signal to noise ratio?

Answer – The signal adds linearly, the noise (being uncorrelated / orthogonal) adds as the square root of the sum of the squares.

Example: Take an image that has a signal of 2 and a noise level of 2. Its initial signal to noise ratio (SNR) is 2/2 = 1.

When we combine (2) images: signal = 2 + 2 = 4, noise = sqrt ($2^2 + 2^2$) = 2.828, SNR = 4/2.828 = 1.414.

When we combine (4) images: signal = 2 + 2 + 2 + 2 = 8, noise = sqrt ($2^2 + 2^2 + 2^2 + 2^2$) = 4, SNR = 8/4 = 2.

*** So, the more images we combine, the better the signal to noise ratio. => Works for lights, darks, flats, flat darks, and bias.

Do you believe it?

Answer - The signal adds linearly, the noise (being uncorrelated / orthogonal) adds as the square root of the sum of the squares.

UNCORRELATED NOISE

Why is this true?

CORRELATED NOISE

Note – there is correlated noise!!

 Combining images does NOT decrease correlated noise.

- Example: Fixed Pattern Noise
 - Use dithering



Pythagorean Theorem y $c^2 = a^2 + b^2$ b а С Х Noise a has no x value uncorrelated Noise b has no y value

2. Gathering Data – Lights, Darks, Flat Lights, Flat Darks, Bias (cont'd)



Example of combining (stacking) 2 signals with noise:

- Signal increases more than noise increases
- Combining signals increases signal to noise ratio (SNR)



Lights

Configure for Dithering





With Dithering

Without Dithering





Completed:

- ✓ Focused
- ✓ Image Framed
- ✓ Backyard EOS Set ready to take sequence of images
- ✓ Backyard EOS & PHD Guiding set for dithering

Left to Do:

- \Rightarrow Set up and start autoguiding
- \Rightarrow Start Backyard EOS image sequence
- \Rightarrow Monitor system for errors



5. Adjust settings

6. Perform calibration

2. Gathering Data – Lights, Darks, Flat Lights, Flat Darks, Bias (cont'd)



 \Rightarrow Monitor system for errors [40x5mins = 3 hours, 20 minutes]

2. Gathering Data – Lights, Darks, Flat Lights, Flat Darks, Bias (cont'd)

Backyard EOS (BYE) Settings

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* Dark current doubles for every approx. 6°C

2. Gathering Data – Lights, Darks, Flat Lights, Flat Darks, Bias (cont'd)

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Light Box Flats

T-Shirt Fl

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2. Gathering Data – Lights, Darks, Flat Lights, Flat Darks, Bias (cont'd)

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□ Set BYE

Backyard EOS (BYE) Settings



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Backyard EOS (BYE) Settings

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3. Processing Image – Align and Stack

Deep Sky Stacker



Click here to load: Lights (Open picture files...) Darks (dark files...) Flat Lights (flat files...) Flat Darks (dark flat files...) Bias (offset/bias files...)



Align / Register: Moves images around so that features line up (translate & rotate). Stack: Combines images to increase Signal to Noise ratio (SNR). 3. Processing Image – Align and Stack (cont'd) Deep Sky Stacker



3. Processing Image – Align and Stack (cont'd) Deep Sky Stacker

Click: Register checked pictures

Click: Recommend Settings





3. Processing Image – Align and Stack (cont'd) Deep Sky Stacker

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Click: Stacking Parameters

3. Processing Image – Align and Stack (cont'd) **Deep Sky Stacker** a state and DeepSkyStacker 3.3.2 Registering and Stacking Open picture files... Select Desired X dat fire ... Stacking Parameters Bat files ... dark fat firs. Changes For: official firs. Light Alignment Result Dark Flat Bias/Offset Intermediate Files Cosmetic 1 Open a File Last. Lights Date Has The Lot Stacking mode Clear List Darks Direct al Entropy Weighted Average Average thesk above a Exestual. (High Dynamic Range) Undied, all Flat Regeter shedled pictures. Median Maximum Compute officets. Bias Interferences of the state of the state Kappa-Sigma clipping 2.00 Kappa: Etc. Median Kappa-Sigma clipping Processing Open picture file. Light Prane Copy current picture to dipboant 5 Number of iterations: Auto Adaptive Weighted Average Create a Star Mask. Score Save pacture to file... 057.04 029.61 999.11 **Dollars** 019-63 Settings... DSS has help Per Channel Background Calibration 957.36 Rev/FITS DOP Settings 004.51 Lood. 6 066.64 files to aid in Savet ... 968.46 Recommended. 960.63 Temporary Files Folder: C:\Users\sdh\AppData\Local\Temp\ ... About SeepStyStadow. 164 44 understand . 939.56 Deep6kyStadier's Help-875.44 Cancel Reduce worker threads priority 642.11 settings 478.69 Use all available processors OK 325.67 952.68 936.65 929.84 1988.07 C/Users/sch/Pictures/Astronomy/HorseHead_Area_122313/122313_Ahitak_IC434_Area_Next_4500_MPCC_CLS_ISO4001 IC434_LIGHT_300s_400se_+10c_C... Light Cillusersisch/Pictures/Astronomy/HorseHead Area, 1223133(122313), Ahibak JCH34, Area, Newt, 4500, MPCC, CLS, 15C4001, IC404_LIGHT_300s_400ss_+10c_C... Light 1980.85 C: Liseniud/Pictures/Actionony/Morserlead_Area_122313(J22313_Ahibak_IC434_Area_Next_4500_NPCC_CL5_J5C400). 0C434_L10HT_300e_400ed_+10t_C... Light 1963.87 -----Main Group / Grout /

Recommended Settings 3. Processing Image – Align and Stack (cont'd) These are recommended settings. They may not work in all the situations but they are often a good starting point. Click on the proposed link to change the setting accordingly Settings that are already set are shown in green You are processing long exposure and possibly good SNR images -> Use AHD debayering If you are using a modded DSLR -> Reset all white balance settings If you are processing narrowband images (especially Hα) -> Use super-pixel mode You are using bias frames Now 'light frames' stacking -> Set the black point to 0 to improve the calibration If you are processing narrowband images (especially $H\alpha$) shows a GREEN selection -> Use Per Channel background calibration You are stacking 40 light frame(s) -> Use Sigma-Clipping combination method or -> Use Auto Adaptive Weighted Average combination method You are creating a master bias from 10 bias frame(s) -> Use Median combination method You are creating a master dark from 10 dark frame(s) -> Use Median combination method You are creating a master flat from 10 flat frame(s) -> Use Median combination method If the resulting images look too gray -> Use Per Channel background calibration If the color balance in the resulting images is hard to fix in post-processing -> Use RGB background calibration OK Cancel

3. Processing Image – Align and Stack (cont'd) Deep Sky Stacker

Start Align & Stack: Click OK

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3. Processing Image – Align and Stack (cont'd) Deep Sky Stacker

Procesing Images

Can Take a Long Time

Approx. 20 minutes on my laptop

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	Estimated remaining time: 1 mn 28 s C/Usersisth/Picturer/Watronom/HonePiesd Area, 122113/(122013_Area, 13:04, Area, 1400_MPCC_0.3_(15:040) C/Usersisth/Picturer/Watronom/HonePiesd Area, 122113(122013_Area, 13:04, 10:04) C/Usersisth/Picturer/Watronom/HonePiesd Area, 122113(122013_Area, 13:04, 10:04) C/Usersisth/Picturer/Watronom/HonePiesd Area, 122113(122013_Area, 13:04) C/Usersisth/Picturer/Watronom/HonePiesd Area, 122113(122013_Area, 13:04)	Stop
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3. Processing Image – Align and Stack (cont'd) Deep Sky Stacker

Displays a version of the aligned and stacked image.

Saves file: Autosave.tif 32bits per color, 116MBytes



3. Processing Image – Post Processing





To go from here to =========→ here We will use: 1) Photoshop Levels, 2) Photoshop Curves, 3) Photoshop Dust & Scratches

Note – Different images require different processing steps Some other common additional steps: Gradient Correction, Other Noise Reduction

3. Processing Image – Post Processing (cont'd)

Step 1: Convert from 32 bits per color to 16 bits per color

[Required to use PS functions]



Photoshop

3. Processing Image – Post Processing (cont'd) Photoshop

Step 2 – Need to balance R,G,B channels – First activate Histogram & Layers





3. Processing Image – Post Processing (cont'd)

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3. Processing Image – Post Processing (cont'd) Photoshop - 🛛 Navigator Info Histogram ۲ She Edit Drage Later Select Filter View Window Help C Channel: Colors Click here Betan Wordson To FE _____ Betan Frank _____ Zoon All Windows _____ Autual Basis _____ He betan 344 Autowent @ 25% (Leves 1. Lever Mark/10) Name I and record to update and Glen 2 9.5 histogram 金 思 and image 0. II. Grund: Grand Integr 4. 4 Heating States 1.6 4. T. with ð. III. Cache Lavel 4 Source: Entire Image 3.1 08 uncached Mean: 15.83 Level: Std Dev: 5.84 Count: STREET, STREET data Median: 16 Percentile: 00 . . . 203 Cache Level: Pixels: 191709 TON Operation 197% FR: 10% 出日が中国 . 5 Oper 70,191/10,181 -0.00.000




S. Douglas Holland







3. Processing Image – Post Processing (cont'd)







3. Processing Image – Post Processing (cont'd)



3. Processing Image – Post Processing (cont'd)

Photoshop



3. Processing Image – Post Processing (cont'd)



3. Processing Image – Post Processing (cont'd)



3. Processing Image – Post Processing (cont'd)

Photoshop



Bring Red up to accentuate the nebula

Create another Curves Adjustment Layer

3. Processing Image – Post Processing (cont'd)



3. Processing Image – Post Processing (cont'd)



3. Processing Image – Post Processing (cont'd)



3. Processing Image – Post Processing (cont'd)



3. Processing Image – Post Processing (cont'd) Photoshop

Step 4: Improve noise and take edge off stars

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Filter => Noise => Dust & Scratches => Radius = 3



4. References

- DSLR Astrophotography by Michael A. Covington
- The Handbook of Astronomical Image Processing by Richard Berry and James Burnell
 - Best book to understand theory of image calibration, comes with AIP4WIN software
- The 100 Best Astrophotography Targets by Ruben Kier
- Photoshop Astronomy by R. Scott Ireland
- Telescopes, Eyepieces, Astrographs by Smith, Ceragioli & Berry
 - Tells the pros and cons of different telescope designs
- Visit my web page:
 - <u>www.holland-observatory.net</u>
 - The presentation posted under 'Astrophotography => Technique'