Digitizing the Cosmos: An Introduction to Astroimaging

by Terry Riopka
President, Skylight Astronomical Society
Feb. 2018

(visit me at www.kantbelievemyeyes.com)

Overview

- free, on-line robotic telescopes
- modest beginnings
  - hardware for acquiring images
  - software for processing raw images
  - software for post processing
- taking pictures of:
  - moon
  - planets
  - deep sky objects
  - International Space Station

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(My) Philosophy of Astroimaging

- Recording the Universe – proof of an external reality
- Challenging the experts

LX200R 10 inch

200 Inch Hale Telescope (1959)

- Embracing narcissism

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Robotic On-line Telescopes

- http://www.itelescope.net

- free demonstration membership
- approximately 30 free minutes access to iTelescope-T3 – a single shot color telescope in New Mexico

1 min exposure

2 min exposure

2 min exposure

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Modest Beginnings: 35mm DSLR

Constellations

Cell Phone

DSLR

Aurora, Milky Way

Web Cam

Cooled CCD

Limited star trails

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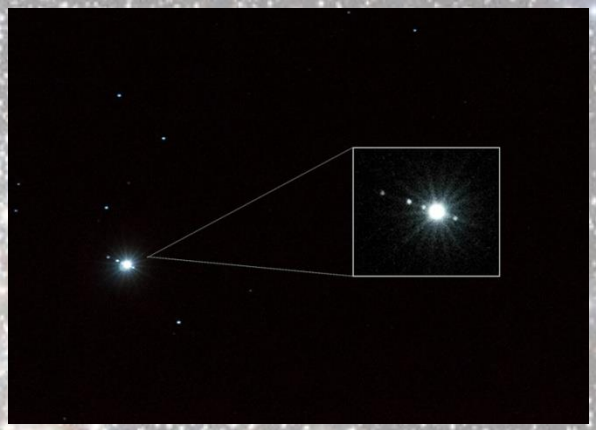
Modest Beginnings:
75-300mm Telephoto + DSLR

Comets

DSLR with
75-300mm Telephoto



Moons of Jupiter

Web Cam

Moon (long distance)

Sunset

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The Moon

300mm Telephoto Lens, with stabalizer

Copyright © Terry P. Riopka 2018

The Moon

300mm Telephoto Lens, with stabalizer, magnified

Copyright © Terry P. Riopka 2018

The Moon

300mm Telephoto Lens, with stabalizer, magnified (sharpened)

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The Moon

LX200R 10 inch Prime Focus with DSLR

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Tracking Mounts

Telescope axis aligned parallel to Earth polar axis

Altazimuth Mount

DSLR

Web Cam

Equatorial Mount

One Tracking Axis + computer (optional)

Two Tracking Axes + computer (required)

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Object Orientation

- as Earth rotates – objects tend to rotate in the sky as shown here

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Object Orientation

- as Earth rotates – objects tend to rotate in the sky as shown here

Copyright © Terry P. Riopka 2018

Equatorial Mount Imaging

- mount rotation causes scope to follow object rotation

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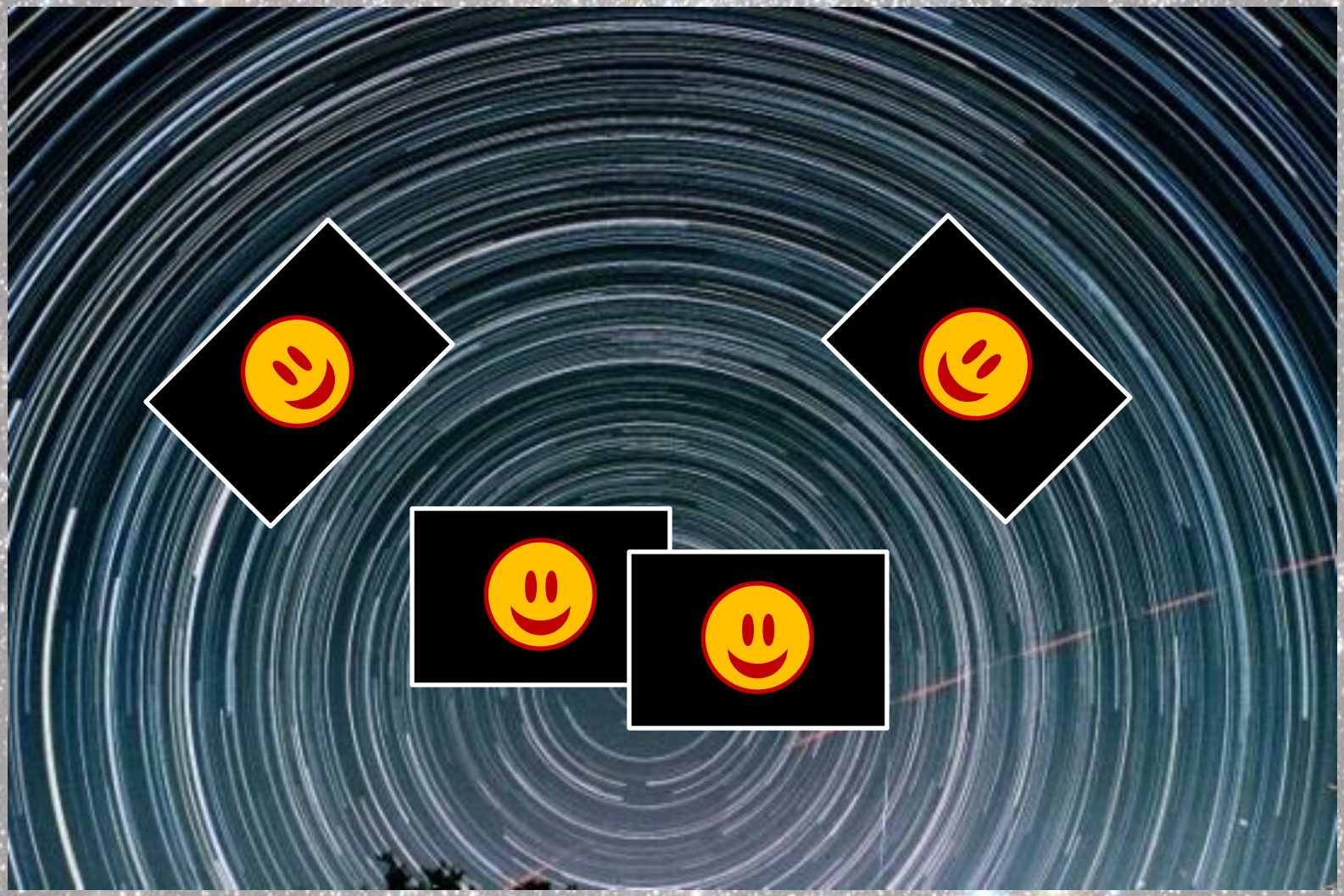
Equatorial Mount Imaging



- **images remain stationary relative to camera**

better alignment → **longer single exposure**

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Altazimuth Mount Imaging

altazimuth mount does NOT follow object rotation

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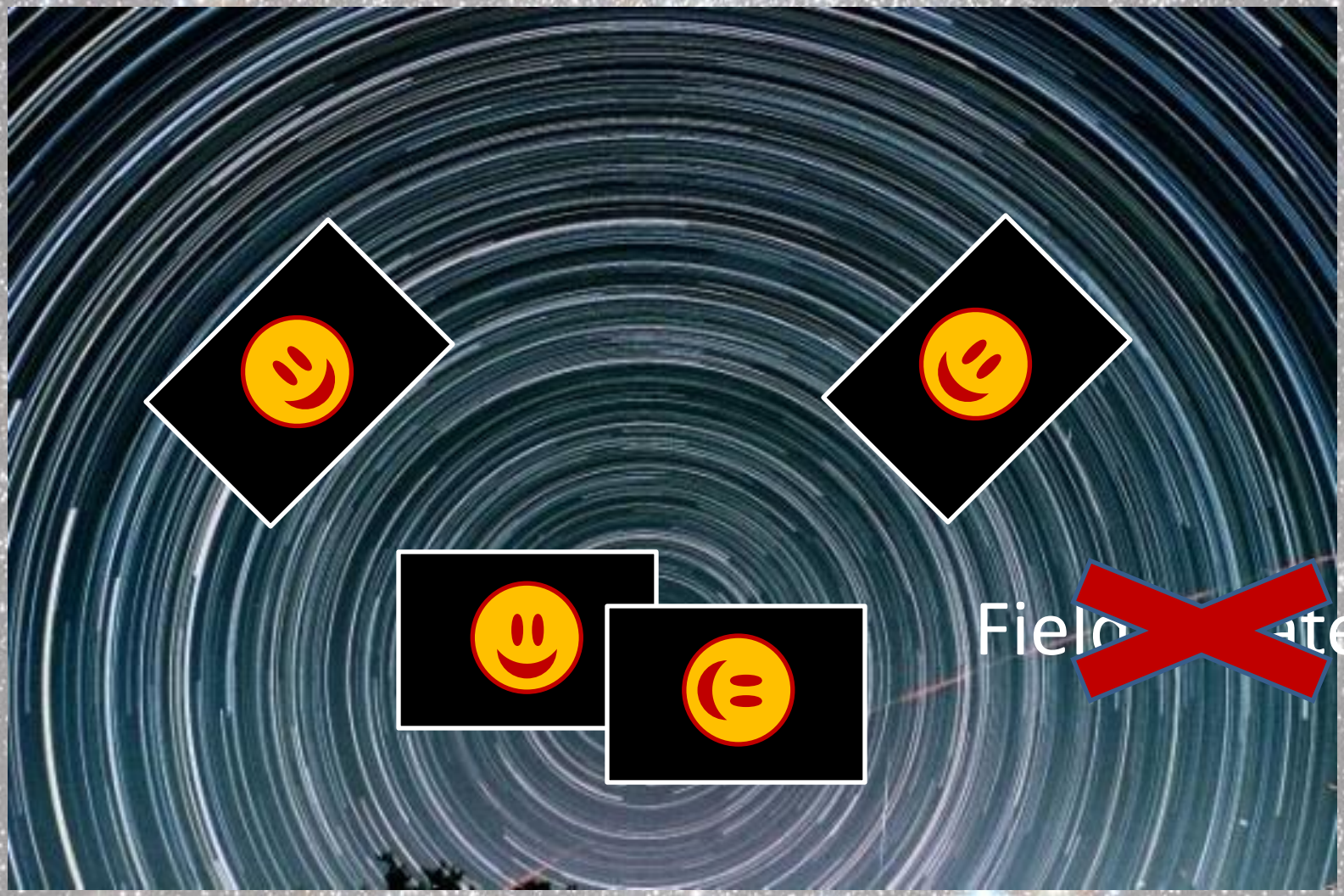
Altazimuth Mount Imaging



- images rotate relative to camera
- Use software to de-rotate multiple short exposures

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Single Long Exposure vs. Multiple Short Exposures (Image Stacking)

1 @ 2000 sec

100 @ 20 sec

Minimum Required:

- Equatorial mount
- Good polar alignment
- Accurate tracking for extended time and/or automatic/manual guiding
- Cooled camera

Minimum Required:

- Accurate tracking for at least 15 – 20 seconds
- DSLR / video
- Registration/Calibration software

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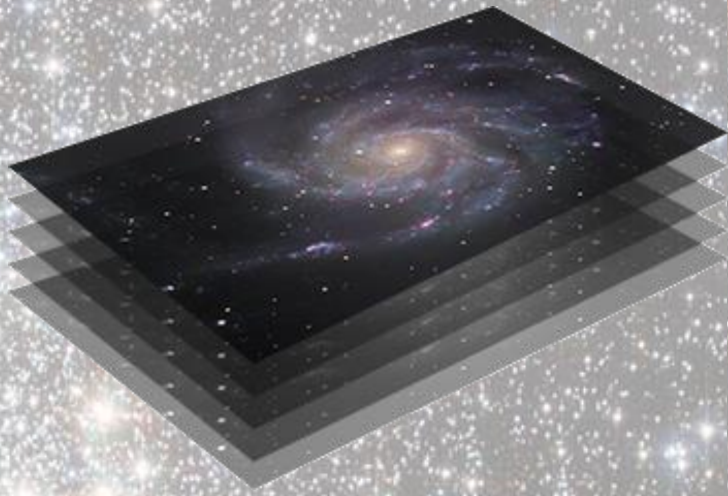
Image Stacking

1 @ 2000 sec



100 @ 20 sec

DSLR FOV - 10” SCT Altazimuth Mount

Use DSLR to acquire 100 “subs” each 20sec exposure

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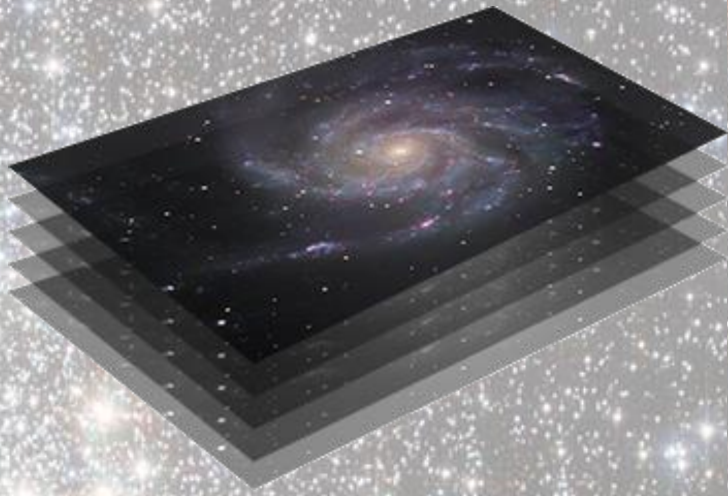
Image Stacking

1 @ 2000 sec



100 @ 20 sec

Use DSLR to acquire 100 “subs” each 20sec exposure

Load all images into stacking program (DeepSkyStacker)

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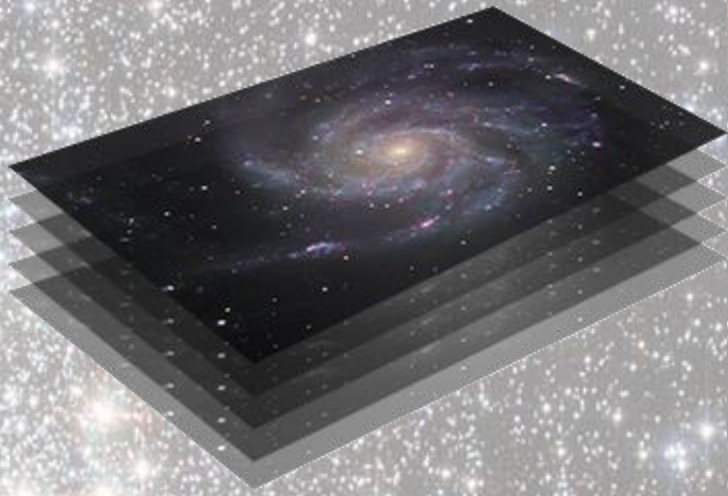
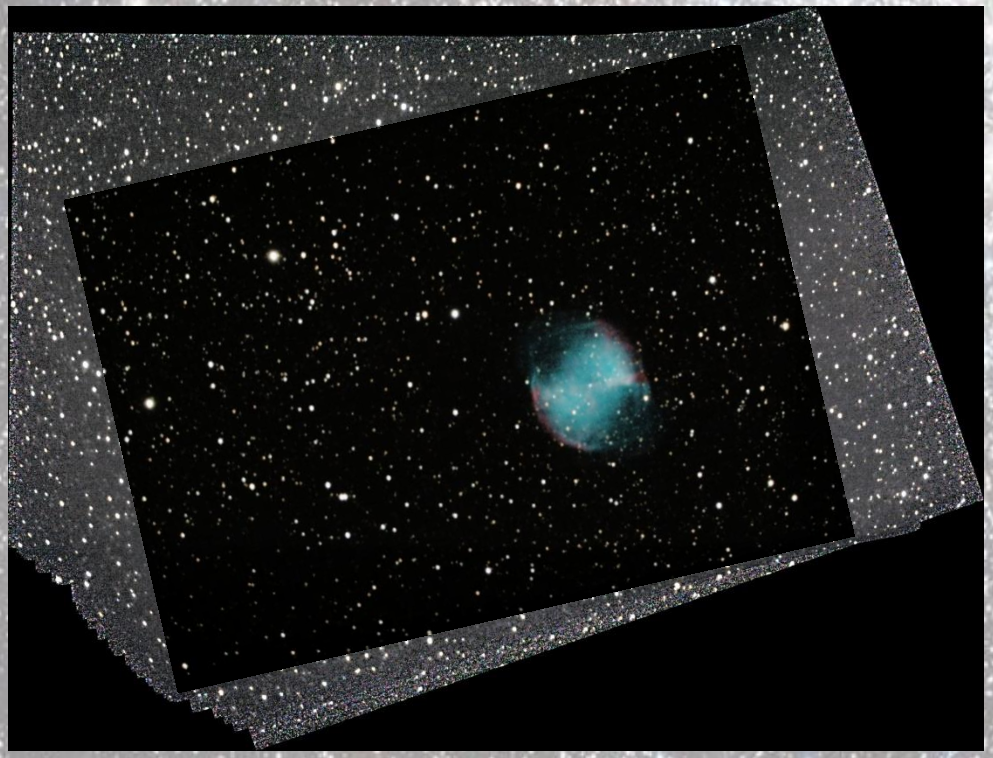
Image Stacking

1 @ 2000 sec



100 @ 20 sec



Use DSLR to acquire 100 “subs” each 20sec exposure

Load all images into stacking program (DeepSkyStacker)

Crop and post-process the final image (DeepSkyStacker and GIMP)

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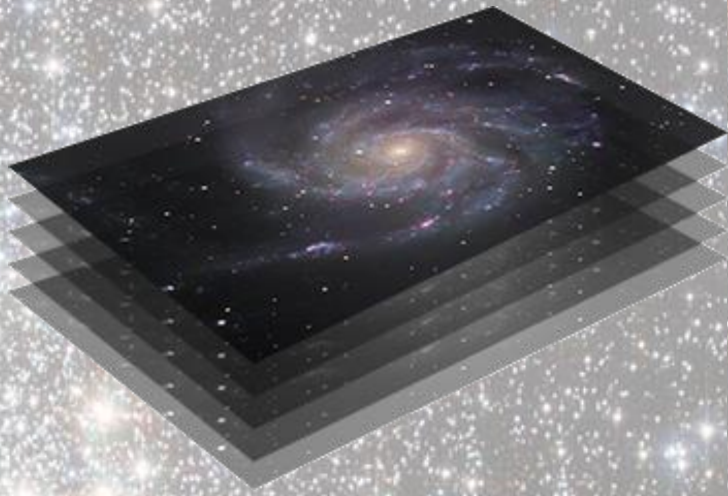
Image Stacking

1 @ 2000 sec



100 @ 20 sec

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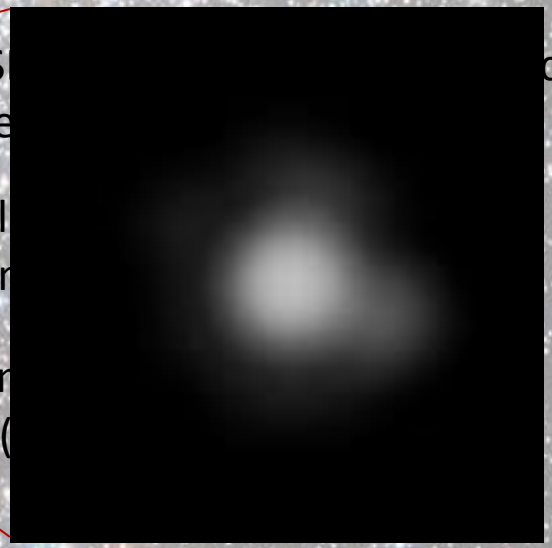
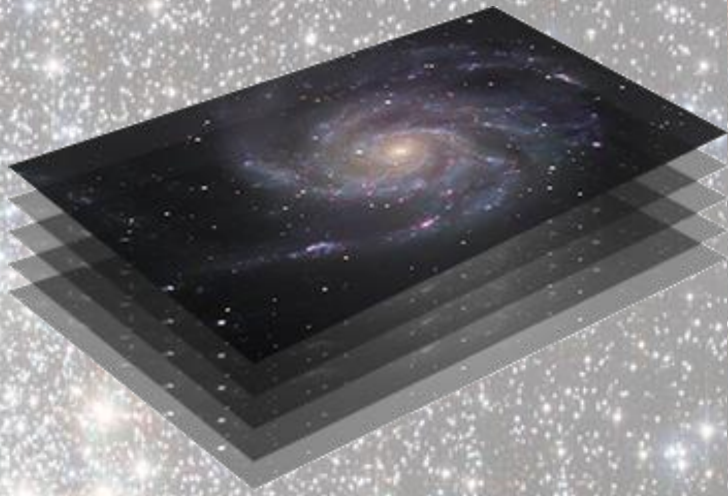


Effect of stacking on star image

Copyright © Terry P. Riopka 2018

Image Stacking

1 @ 2000 sec



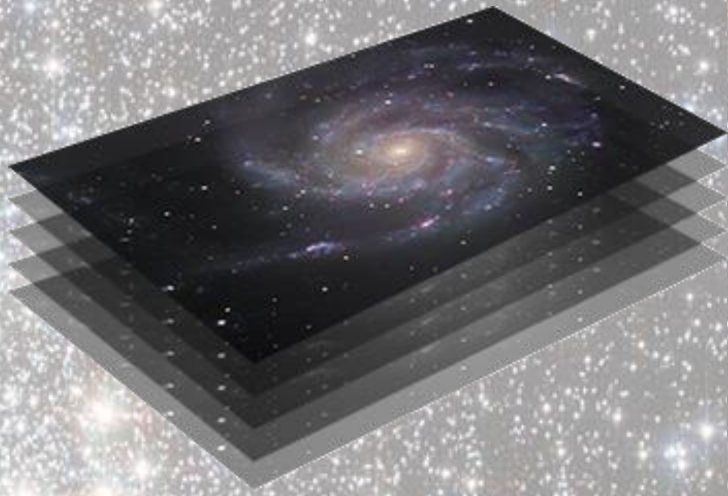
100 @ 20 sec

Effect of stacking on star image

Copyright © Terry P. Riopka 2018

Image Stacking

1 @ 2000 sec



100 @ 20 sec

Effect of stacking on star image

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Adapting DSLRs For Astroimaging

35mm (Standard Lens)

75-300mm (Telephoto Lens)

www.telescopeadapters.com

www.scopestuff.com

Prime Focus (Telescope "Lens")

2 inch Ultra-wide Prime Focus Adapter Specific to Camera

To Telescope

Camera Body

OR

T-Ring Specific to Camera

T-Adapter (1.25")

To Telescope

Diagonal

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Adapting DSLRs For Astroimaging

35mm (Standard Lens)

www.telescopeadapters.com

www.scopestuff.com

75-300mm (Telephoto Lens)

For wider angle imaging (preferred)

Camera Body

OR

Focal Reducer
(Optec Lepus 0.62x)

To Telescope

Diagonal

Copyright © Terry P. Riopka 2018

35mm DSLR piggybacked on altazimuth mounted telescope, single image, 20sec exposure
0’
180’
360’
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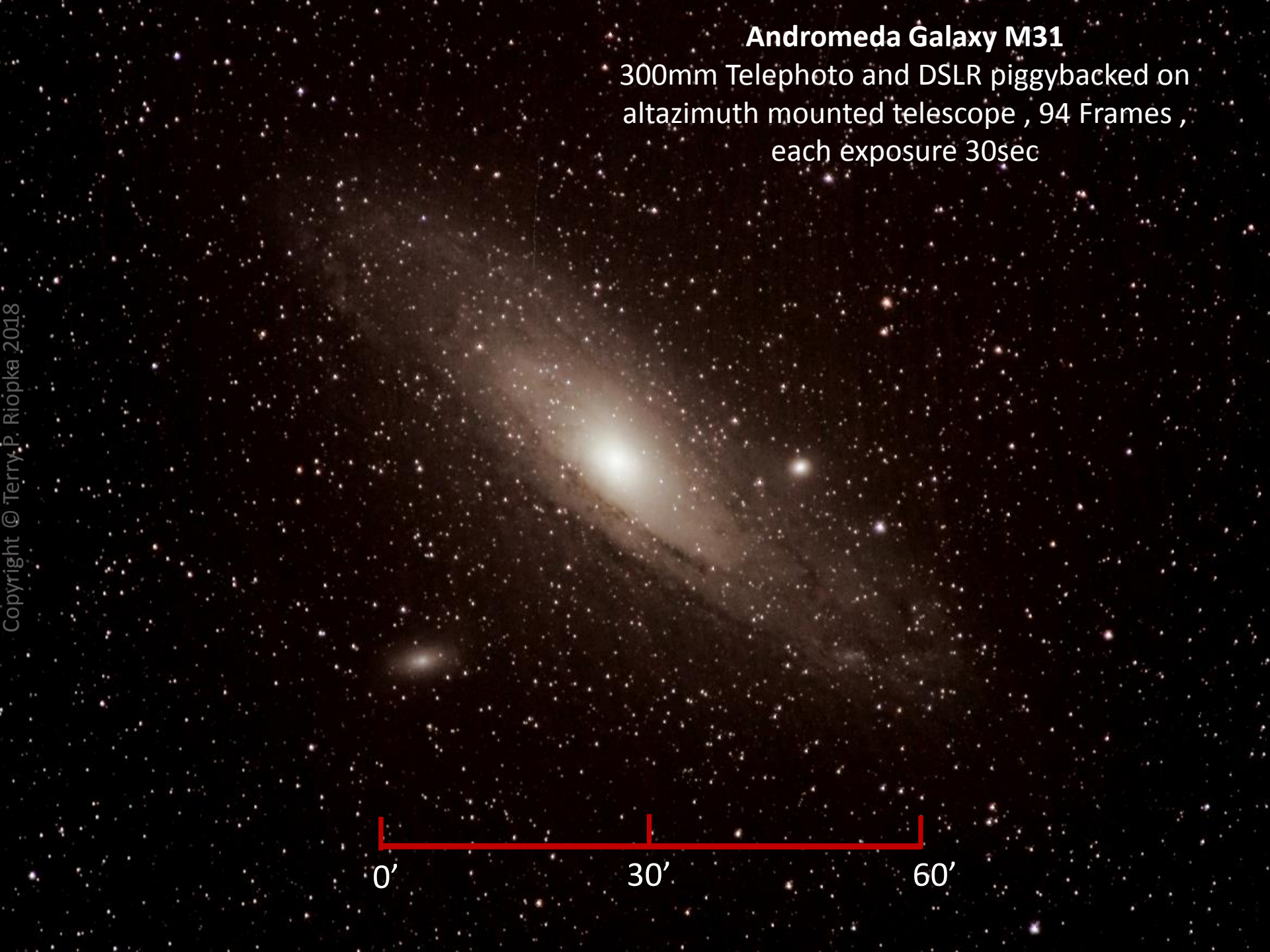
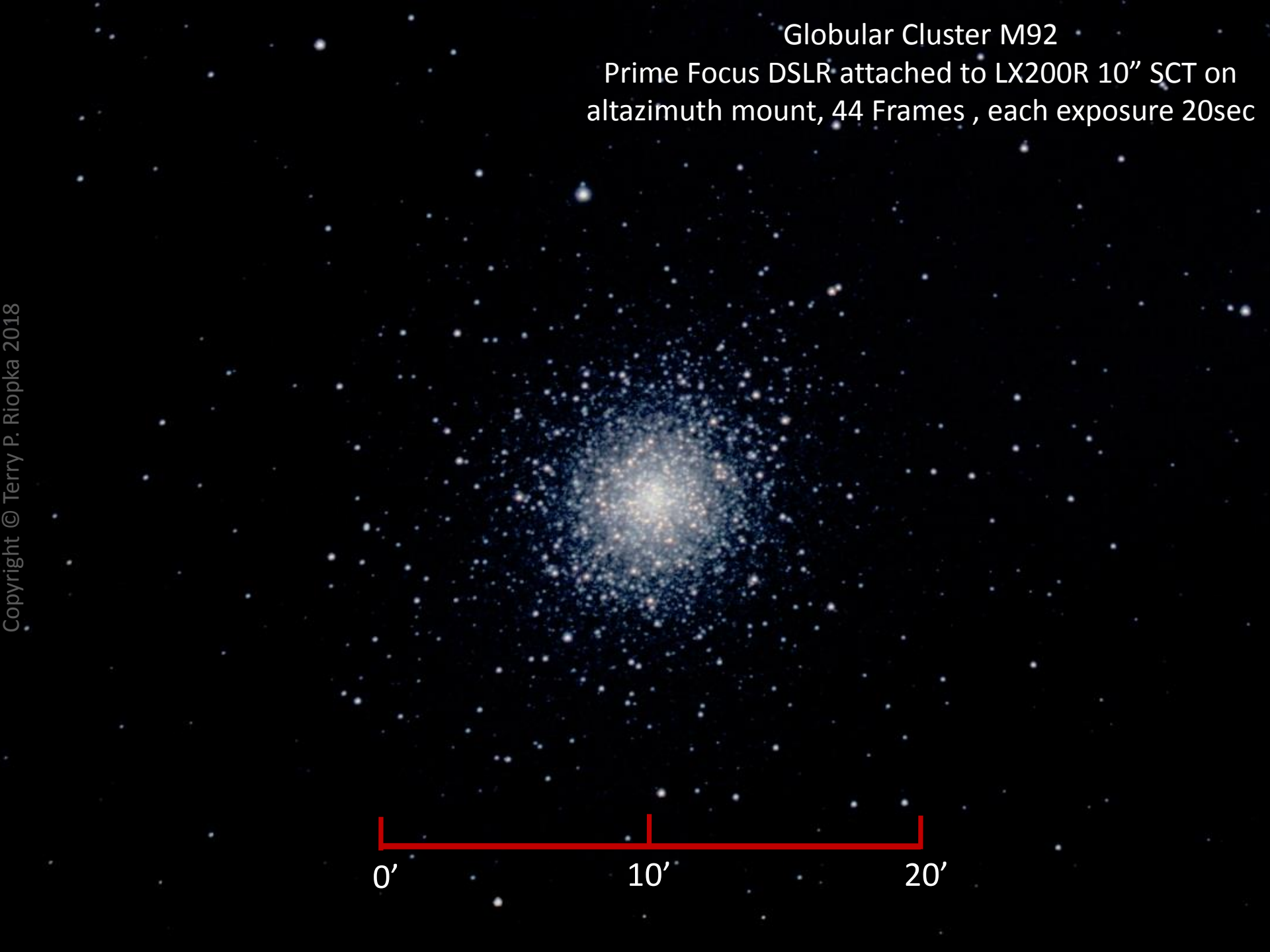

Andromeda Galaxy M31
300mm Telephoto and DSLR piggybacked on altazimuth mounted telescope , 94 Frames , each exposure 30sec
0’
30’
60’
Copyright © Terry P. Riopka 2018



Copyright © Terry P. Riopka 2018

Orion Nebula M42

DSLR with 0.62x Focal Reducer
attached to LX200R 10” SCT on altazimuth mount,
78 Frames , each exposure 20sec

0’ 10’ 20’ 30’ 40’

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Required Accessories

LCD Timer
Remote Control
(Intervalometer)

Bahtinov Mask

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(My) Procedure for Taking Astrophotos of Deep Sky Objects (DSOs)

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1. Setup and align telescope.
2. GOTO the DSO and synch on it
3. GOTO any bright star near DSO of interest
4. Attach DSLR & remote, achieve coarse focus, and lock mirror
5. Attach Bahtinov mask and achieve fine focus
6. REMOVE Bahtinov mask
7. GOTO the DSO
8. Finalize framing / exposure / number of images etc.
9. Start image acquisition

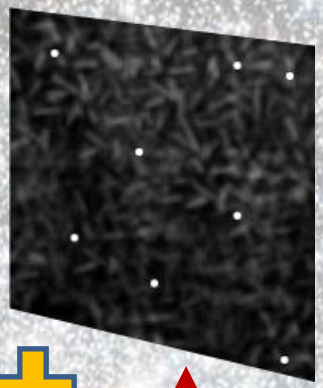
DeepSkyStacker (DSS) and the Imaging Process

Raw Photon Data (Signal)

×

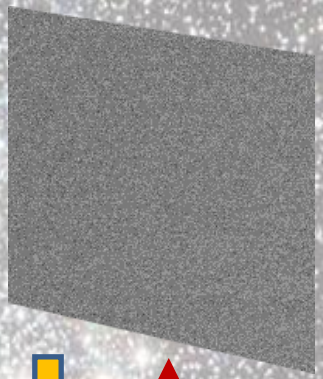
Noise due to vignetting, pixel non-uniformities and dust/dirt on imaging surfaces (Flats)

+



Camera Thermal Noise (Raw Darks)

+



Read-out Noise (Bias)

=

Final Digitized Image (Lights)

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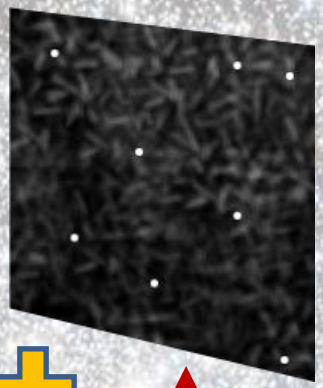
DeepSkyStacker (DSS) and the Imaging Process

Raw Photon Data (Signal)

×

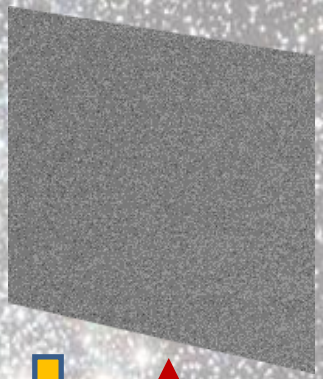
Noise due to vignetting, pixel non-uniformities and dust/dirt on imaging surfaces (Flats)

+



Camera Thermal Noise (Raw Darks)

+



Read-out Noise (Bias)

=

Final Digitized Image (Lights)

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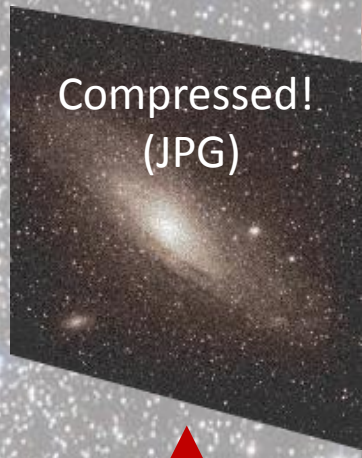
DeepSkyStacker (DSS) and the Imaging Process



≈

Final Digitized Image only an approximation of the "real" thing

How do we get back closer to the original?

Final Digitized Image (Lights)

Raw Photon Data (Signal)

You can start by stacking only JPG compressed Lights!

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DeepSkyStacker (DSS) and the Imaging Process

Better!

Final Digitized Image (Lights)

≈

Raw Photon Data (Signal)

Final Digitized Image only an approximation of the "real" thing

How do we get back closer to the original?

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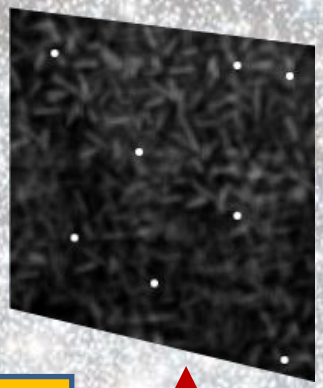
DeepSkyStacker (DSS) and the Imaging Process

Raw Photon Data (Signal)

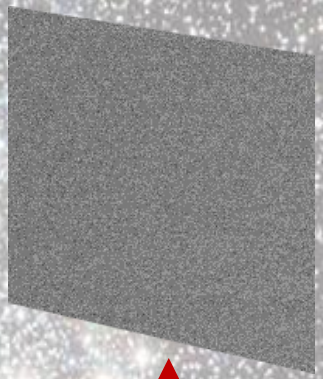
≈



Better!!

Camera Thermal Noise (Raw Darks)

−



Read-out Noise (Bias)

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Darks

Better!

Final Digitized Image (Lights)

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DeepSkyStacker (DSS) and the Imaging Process

Raw Photon Data (Signal)

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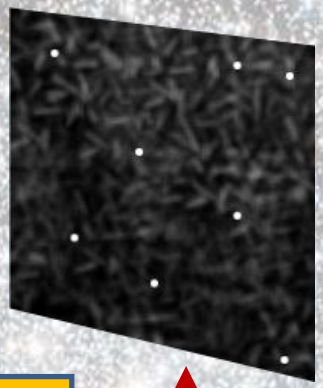
Even better!!

Noise due to vignetting, pixel non-uniformities and dust/dirt on imaging surfaces (Flats)

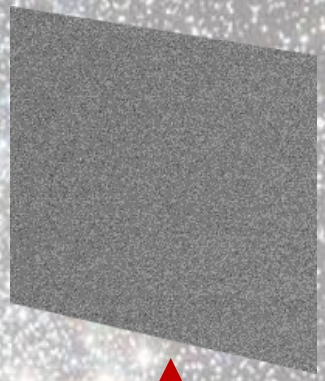
−



Better!!

Camera Thermal Noise (Raw Darks)

−



Read-out Noise (Bias)

Darks

Better!

Final Digitized Image (Lights)

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Post-Processing Programs

Image Stacking Programs

DeepSkyStacker

AstroVideo

IRIS

ImagesPlus

AstroArt

MaximDL

PixInsight

Nebulosity

(Free) Image Processing Programs

GIMP (http://www.gimp.org)

UFRaw (http://ufraw.sourceforge.net) GIMP plugin for handling 16 bit images)

GOTO → **DeepSkyStacker**

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Planetary Imaging

Main Factors affecting planetary imaging:

- Telescope aclimatization
- Seeing conditions
- Collimation

Mars before collimation

Mars after collimation (next day)

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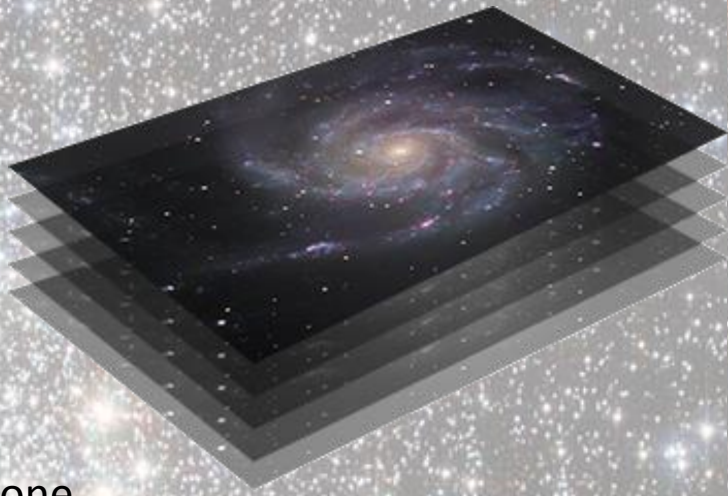
Image Stacking for Planetary Imaging

1 @ 2000 sec

- *could* use camera to acquire one picture at a time, each exposed as long as stable tracking allows



100 @ 20 sec

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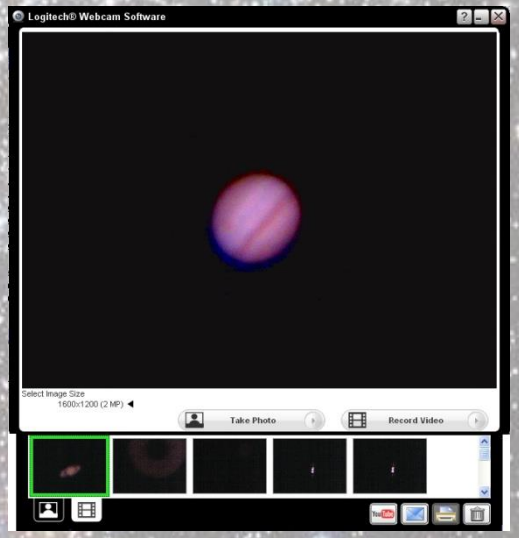
1 @ 30 sec.

Instead – use "lucky" imaging and stacking

- Use web cam or video camera to acquire a video stream of images as long as planet feature rotation allows



1800 @ 1/60 sec.

Image Acquisition and PostProcessing

1. Acquire 1-2min movie

2. Crop original movie (optional)

.wmv file (Windows Movie File) → **Castrator.exe** → .wmv file (Cropped)

3. Convert to AVI

.wmv file (Windows Movie File) → **STOIK Video Converter** → .avi file (Uncompressed)

4. Load AVI file into RegiStax to split up, sort frames and stack

GOTO → **RegiStax**

5. Open resulting image in GIMP for final processing

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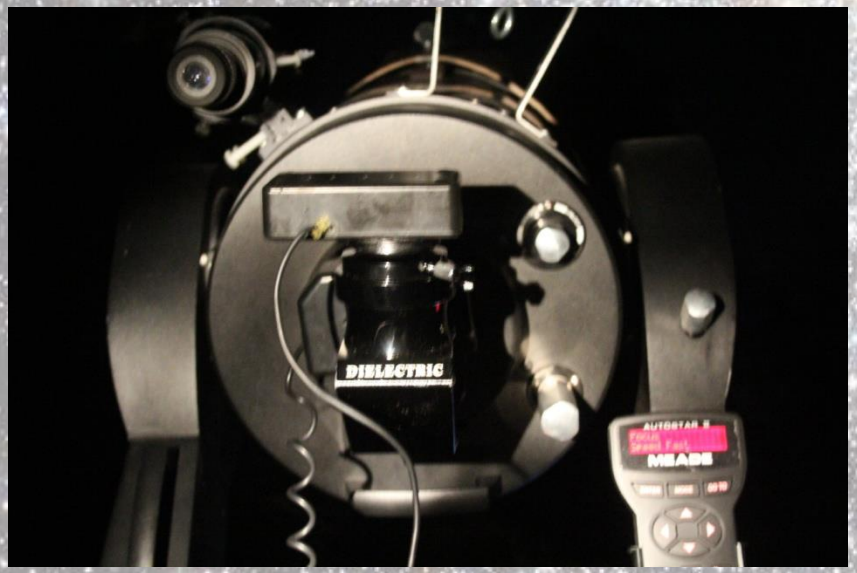
Adapting a Logitech 9000 Web Cam for Astroimaging

http://ghonis2.ho8.com/Pro9000mod.html

Disassemble Logitech 9000 web cam

Transfer circuit board with CCD chip to project box

Web Cam at Prime Focus



Glue T-Ring to project box and screw in 1.25” Adapter

- Currently using **Celestron Skyris 132c single shot color camera with a Powermate 2.5X**

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(My) Procedure for Image Acquisition of Planetary Objects

1. Setup and Align your Telescope (does not have to be very accurate)
2. Find and center the planet of interest in your FOV.
3. Turn on your web cam for live view, and swap out your eyepiece for the web cam
4. Bring the planet into coarse focus, recenter, and adjust exposure/brightness/contrast for the web cam
5. Bring the planet into fine focus.
6. Begin image acquisition

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Image Acquisition : Mars

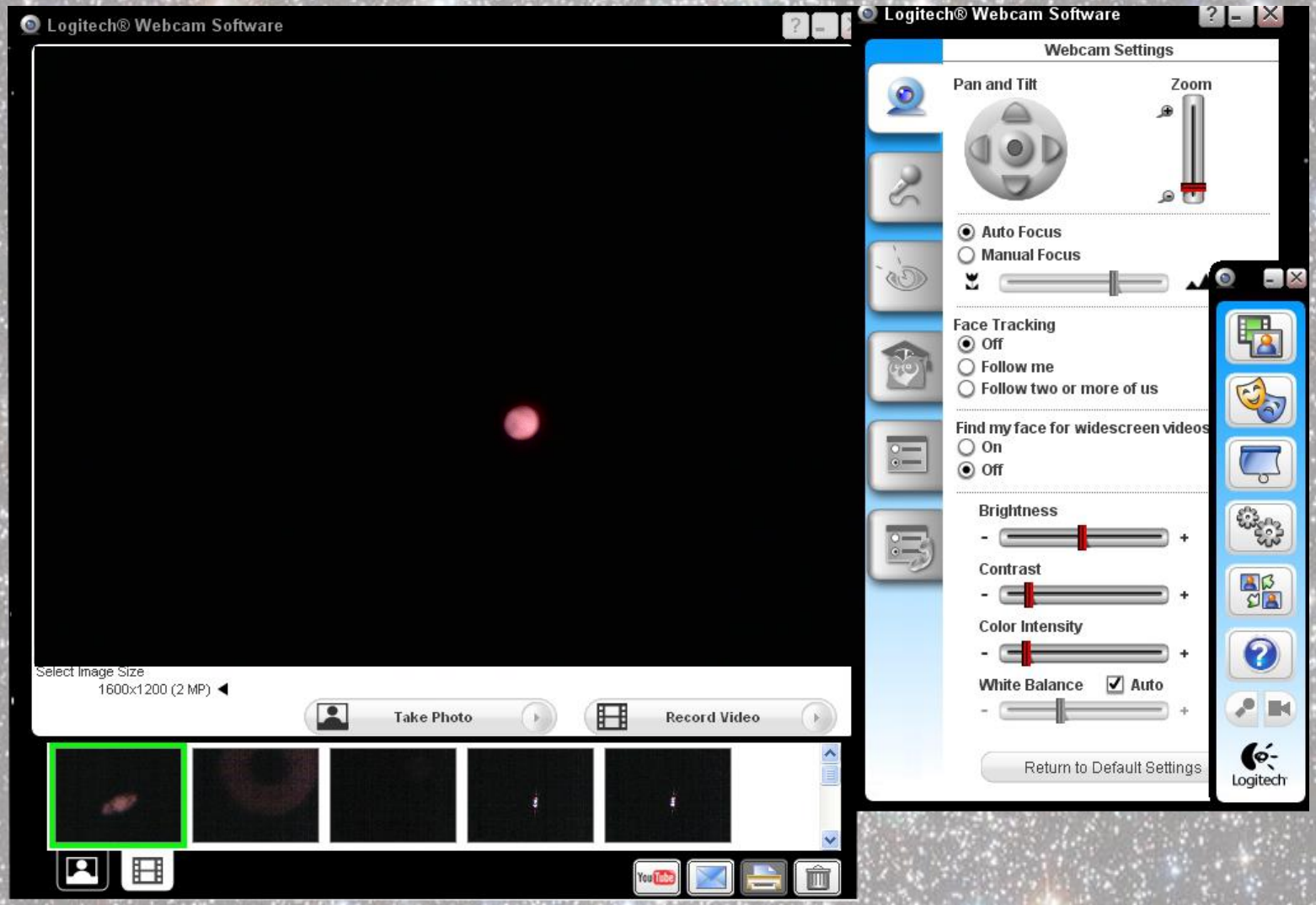

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Image Acquisition : Saturn

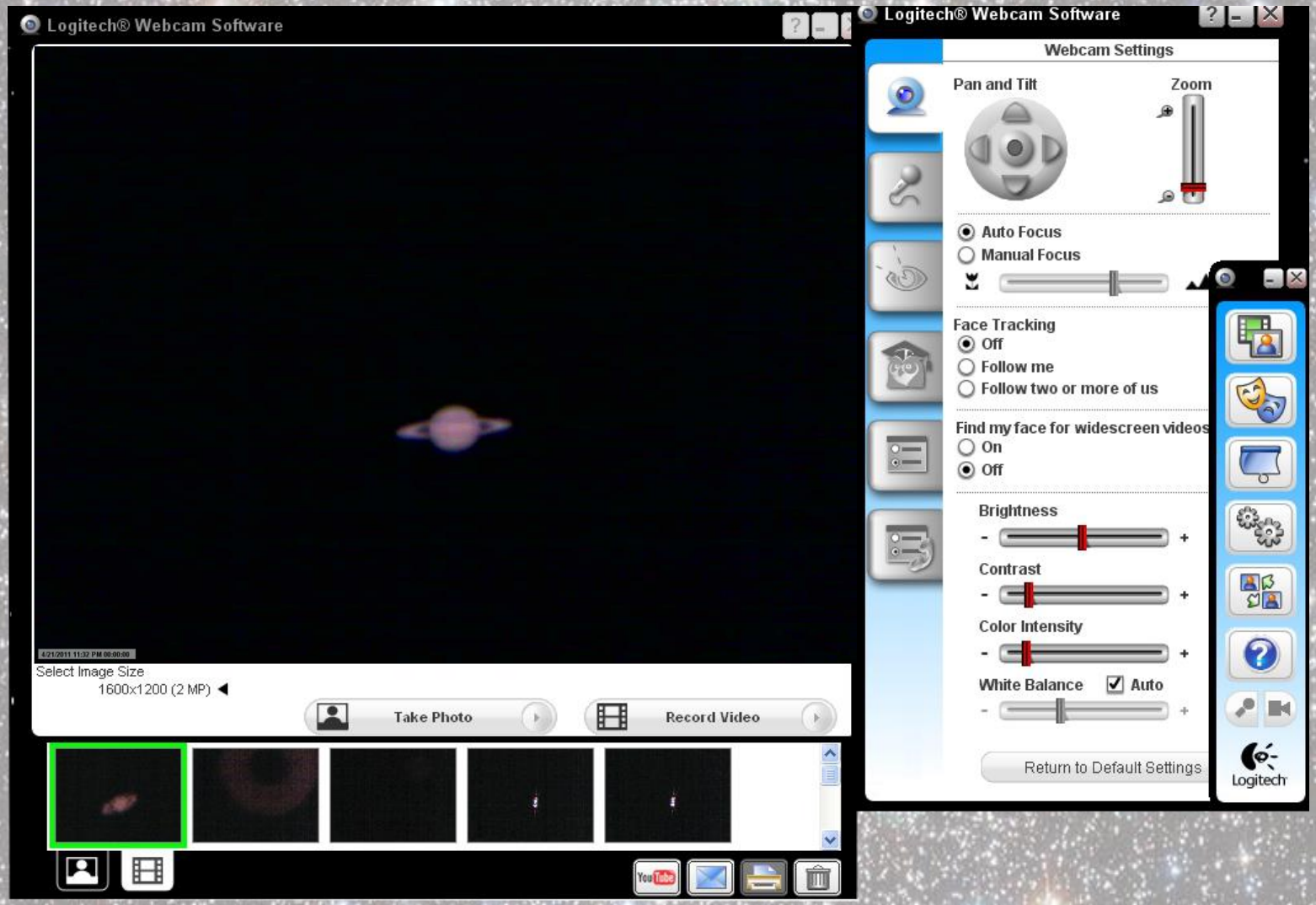

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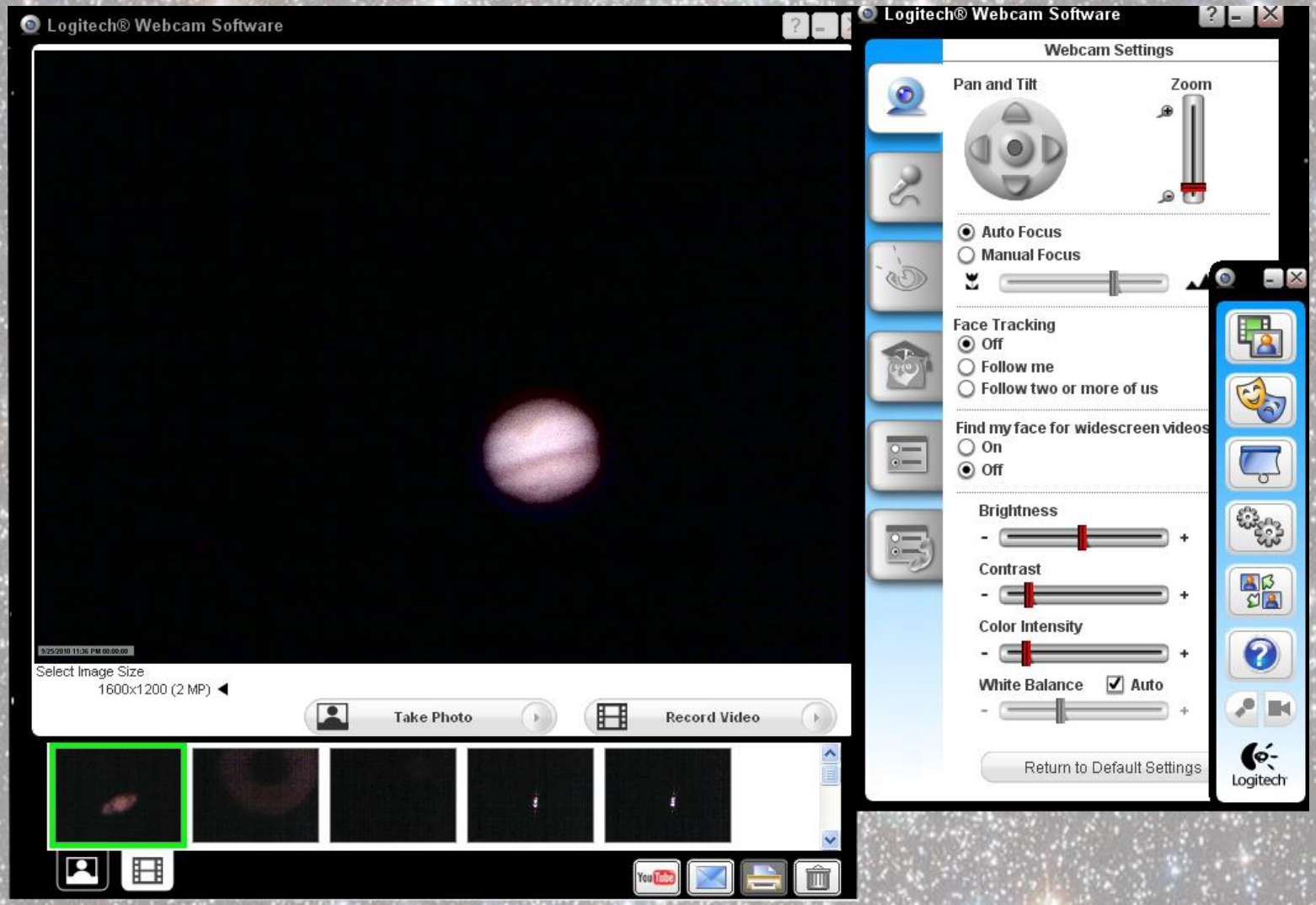
Image Acquisition – Jupiter Under Bad Conditions



Atmospheric conditions can make a HUGE difference!

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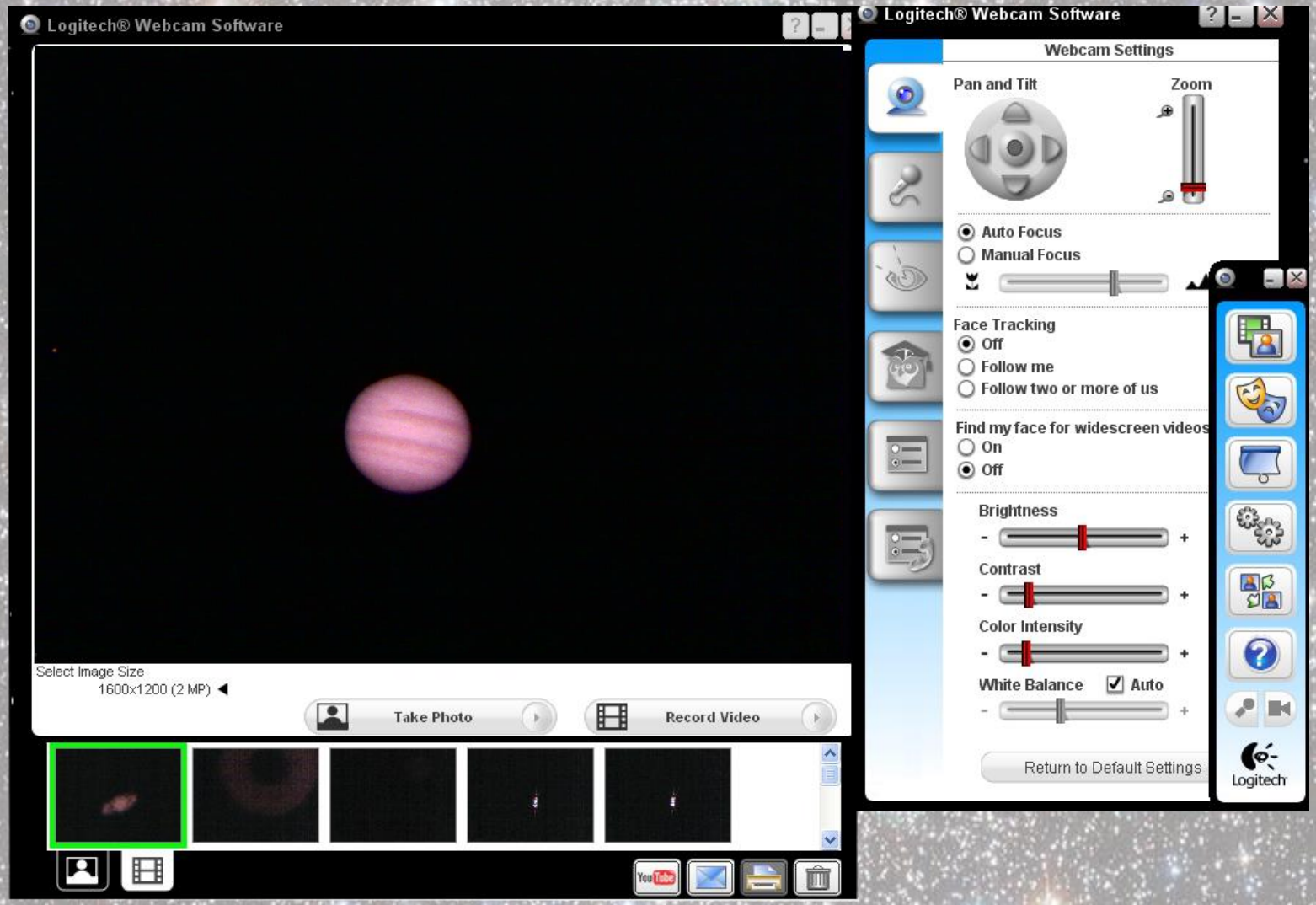
Image Acquisition – Jupiter Under Good Conditions



Atmospheric conditions can make a HUGE difference!

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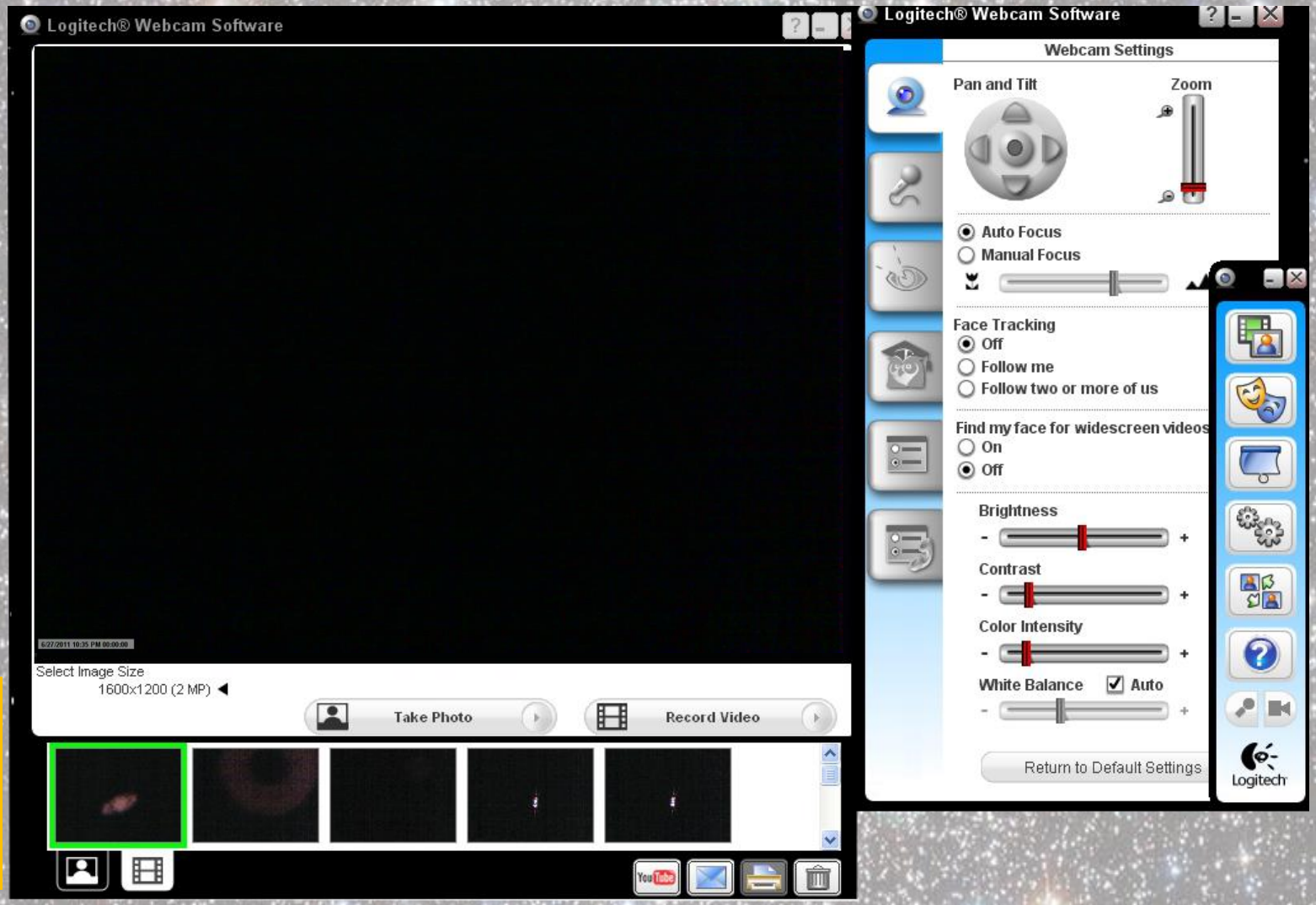
Image Acquisition – Space Station



Watch for time indices 00:33:00 and 00:57:00

- Due to poor tracking, manual adjustments needed to "catch" the ISS in a frame
- Frames are not stacked – only single frames are extracted and used

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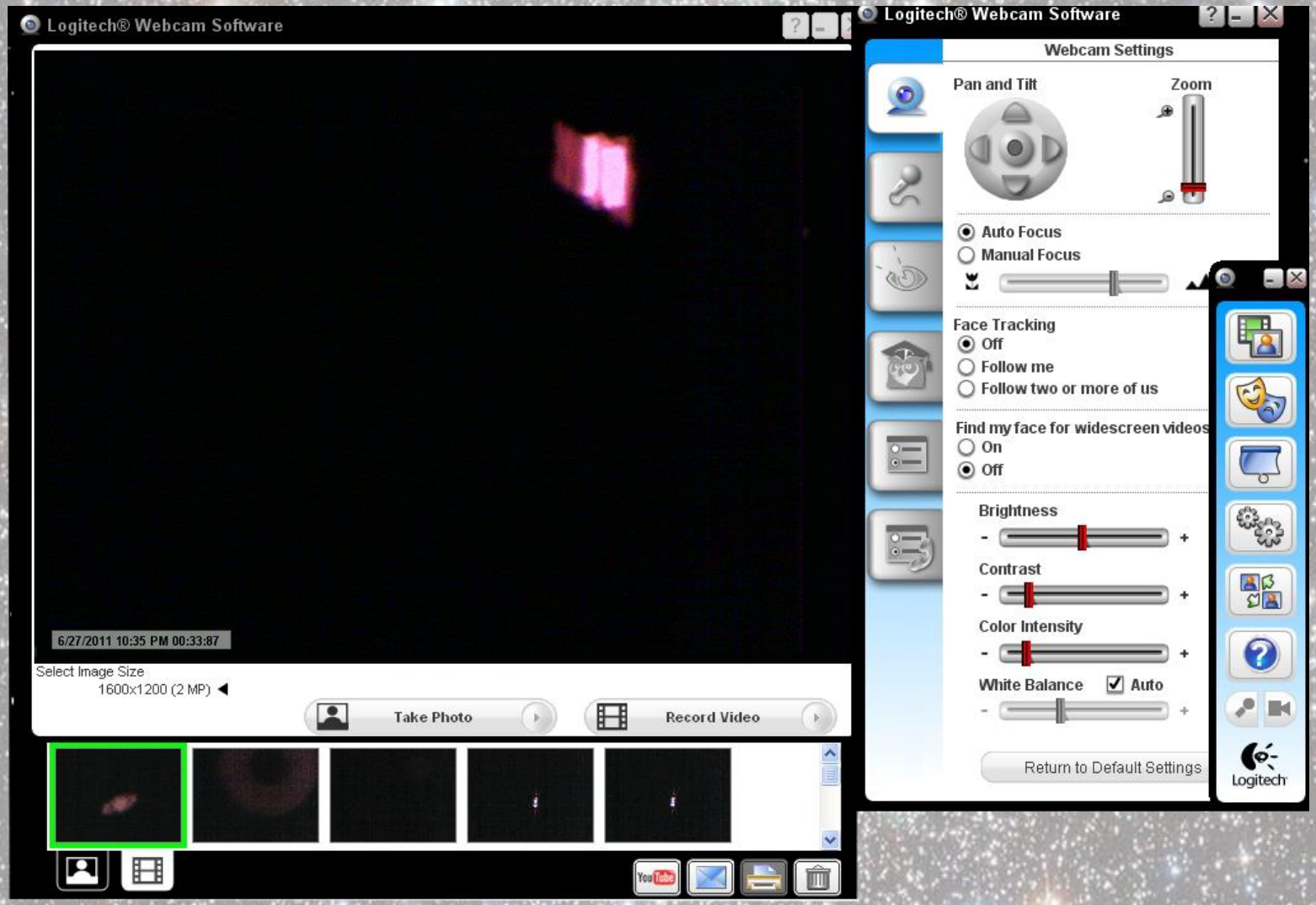
Image Acquisition – Space Station



- Due to poor tracking, manual adjustments needed to "catch" the ISS in a frame
- Frames are not stacked – only single frames are extracted and used

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1006 images stacked in Registax, extracted from 1 minute of video taken with Logitech 9000 Webcam, Prime Focus, using LX200R 10” SCT on altazimuth mount, post-processed in GIMP

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1080 images stacked in Registax, extracted from 1.5 minutes of video taken with Logitech 9000 Webcam, Prime Focus, using LX200R 10” SCT on altazimuth mount, post-processed in GIMP

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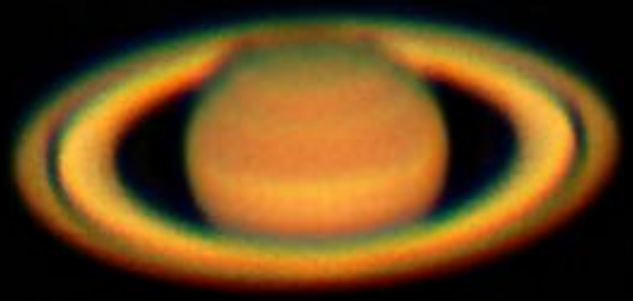
2815 images stacked in Registax, extracted from 1 minute of video taken with a Skyris 132c, through a 2.5X PowerMate on an LX200R 10” SCT with altazimuth mount, post-processed in GIMP



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Thank you!

DeepSkyStacker@yahoogroups.com

RegiStax@yahoogroups.com

ISStracking@yahoogroups.com

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