Astrophotography
Tales of Trial & Error

Dave & Marie Allen
Contents

Photos Through Camera Lens

1 Star trails
2 Piggy back

Photos Through the Telescope

3 Prime focus
4 Photo through the eyepiece
5 Eyepiece projection
Camera Basics

When the photograph is being exposed, the light is directed onto the film. The viewfinder is completely black.

Usual photographic rules apply:

- Less light $\rightarrow$ Longer exposures
- Higher $f$ number $\rightarrow$ Longer exposures

Light directed to viewfinder

Light directed to film
Star Motion

Stars rise and set – just like the Sun in the daytime.
The motion of the stars can cause problems for astrophotography
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Stars rise and set – just like the Sun in the daytime. The motion of the stars can cause problems for astrophotography.

Tracking the motion of the stars during the exposure is called “guiding”.

Requires a polar aligned mount and periodic corrections to keep the subject stationary relative to the camera.

Done using slow motion controls – or more often with dual axis correctors.
Guiding

<table>
<thead>
<tr>
<th>Photography Technique</th>
<th>Guiding Required?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Star trails</td>
<td>No</td>
</tr>
<tr>
<td>Piggy back</td>
<td>Yes</td>
</tr>
<tr>
<td>Prime focus</td>
<td>Yes</td>
</tr>
<tr>
<td>Photo through the eyepiece</td>
<td>No – but tracking helps</td>
</tr>
<tr>
<td>Eyepiece projection</td>
<td>No – but tracking helps</td>
</tr>
</tbody>
</table>
Star Trails

Mount the camera on a tripod
Point at stars
Open the shutter for 30 mins to 2 hours

Red Rock Canyon
50mm lens @ f/2
100 ASA Film
~1 hour exposure

Can you tell which direction
The camera was pointing?
(North, South, East or West)
Creative Freedom

• Composition
  • Camera Angle / Direction
  • Field of View
  • Silhouette / Illuminated Foreground

• Subjects
  • Aurora
  • Meteor Showers
  • Dramatic Foreground

Equipment

• Sturdy tripod
• Locking cable release
• Camera with ‘B’ setting
• Patience

Problems

• Lights – Film is sensitive to light pollution
• Photo Developers – Unusual to get dark skies from photo lab
• Framing – Difficult to see foreground

Solutions

• Find dark site or use light to help with composition
• Write “Astronomy Photos – Please Expose For Dark Sky” on envelope (or use custom developer)
• Practice!
Example Star Trails

Red Rock Canyon
50mm lens @ f/2
100 ASA Film
~1 hour exposure
Example Star Trails

Saddle Back Butte
28mm lens @ f2.8
100 ASA Film
~1 hour exposure
Piggy Back Astrophotography

Mount camera on top of equatorially mounted telescope
Aim at subject and carefully track the movement of the stars
Open the shutter for 5 mins to 2 hours

Nebulosity in Orion
Quartz Hill
300 mm lens @ f4.5
800 ASA Film
~20 min exposure
Auto guided
Piggy Back Astrophotography

Creative Freedom

• Composition – Limited Options
  • Field of View (Focal Length of Lens)
  • Special Effects with Filters

• Subjects
  • Constellations
  • Large Galaxies

Equipment

• Equatorial mount (or “Barn Door” mount)
• Brackets – camera to telescope / counter weight shaft
• Locking cable release
• Camera with ‘B’ setting
• Guiding equipment
• Lots of Patience

Problems

• Lights, Photo Developers, Framing
• Polar Alignment – Essential to minimize ‘Field Rotation’
• Exposure
  • Low contrast if too short
  • Sky fog if too long
• Guiding – Difficult to prevent stars drifting
Piggy Back Astrophotography

Problems

• Polar Alignment – To prevent ‘Field Rotation’
• Exposure for dim subjects
  • Low contrast if too short
  • Sky fog if too long
• Guiding – Difficult to prevent stars drifting

Solutions

• Declination drift or polar alignment scope
• Bracket exposures
  • Use fast film (400 ASA or faster)
  • Need dark sky
• Need a guiding eyepiece or auto guider

Auto guiders
Relentless precision of machine
Expensive (5x cost of eyepiece)
Limited applications

Guiding Eyepiece
Human precision (!)
Needs constant attention
Multiple uses
Example Piggy Back Photographs

Andromeda Galaxy

Red Rock Canyon
500 mm lens @ f/8
800 ASA Film
~45 mins exposure

Auto guided
Example Piggy Back Photographs

Horse head Nebula (NGC B33)

Quartz Hill
300 mm lens @ f4.5
800 ASA Film

(Enlargement of previous photograph)

Auto guided
Prime Focus Astrophotography

Mount camera to look through telescope
Aim at subject and carefully track the movement of the stars
Open the shutter for 1/1000 sec to 2 hours

Orion Nebulae (M42 & M43)
Quartz Hill
C8 Telescope @ f6.3
800 ASA Film
15 min exposure

Auto guided
Prime Focus Astrophotography

Creative Freedom

• Composition – Limited Options
  • Field of View (Telescope Focal Length)

• Subjects
  • Extended Deep Sky Objects
  • Galaxies
  • Globular Clusters
  • Nebulae
  • Sun & Moon

Equipment

• Telescope with equatorial mount
• Camera adapter
• Focus equipment
• Locking cable release
• Camera with ‘B’ setting
• Guiding equipment
  • Guide scope
  • Off axis guider
• Even More Patience!!

Problems

• Lights, Photo Developers, Framing
• Polar Alignment, Guiding, Exposure
• Guiding (again)!
• Focusing – subjects may be invisible!
Guiding Prime Focus Photos

Off Axis Guiders

<table>
<thead>
<tr>
<th>Plus</th>
<th>Minus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good accuracy – uses the focal length of the telescope</td>
<td>Can sometime be difficult to find a guide star in the field of view</td>
</tr>
<tr>
<td>Small and light</td>
<td>Not always easy to reach focus with eyepiece</td>
</tr>
</tbody>
</table>
### Guiding Prime Focus Photos

**Separate Guide scope**

<table>
<thead>
<tr>
<th>Plus</th>
<th>Minus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to find guide stars</td>
<td>More bulky equipment</td>
</tr>
<tr>
<td>Independent focusing of camera and guiding eyepiece / auto guider</td>
<td>Flex between telescope and guide scope causes guiding errors</td>
</tr>
<tr>
<td></td>
<td>Less accurate than off axis guider</td>
</tr>
</tbody>
</table>
Focusing Invisible Subjects

There are a huge number of gadgets to help with focusing.
This indicates the seriousness of the problem!!

Film plane focusing

Bright focusing screens

Focusing masks

Viewfinder magnifiers
Example Prime Focus Photos

Whirlpool Galaxy (M51)

Quartz Hill
C8 @ f10
800 ASA Film
~30 mins exposure

Auto guided

(Enlargement)
Example Prime Focus Photos

Orion Nebulae
(M42, M43 & NGC 1977)

Quartz Hill
C5 @ f6.3
800 ASA Film
~15 mins exposure

Auto guided
Pinwheel Galaxy (M33)

Mount Pinos
C8 @ f10
800 ASA Film
~60 mins exposure

Auto guided
Example Prime Focus Photos

Crab Nebula (M1)
Quartz Hill
C8 @ f10
800 ASA Film
~45 mins exposure
Auto guided
(Enlargement)
Example Prime Focus Photos

Hercules Cluster (M13)

Saddle Back Butte
C8 @ f10
800 ASA Film
~15 mins exposure

Auto guided
Example Prime Focus Photos

Lagoon Nebula

Quartz Hill
C8 @ f10
800 ASA Film
20 min exposure
Example Prime Focus Photos

Moon

Quartz Hill
C8 @ f10
200 ASA Film
1/125 sec exposure

Recognize any features?
Prime Focus Photos Have Correct Orientation
Example Prime Focus Photos

WARNING!

Use solar filter over objective!
Cover / remove finder scope!
Remove Telrad!
Do not look at the sun!

Sun

Quartz Hill
C5 @ f10
100 ASA Film
1/1000 sec exposure

Quartz Hill
C8 @ f10
100 ASA Film
1/1000 sec exposure
Subject Selection

35mm Field Of View - Prime Focus

Long side (deg) = 2073 / focal length (mm)
Short side (deg) = 1382 / focal length (mm)

Examples:

<table>
<thead>
<tr>
<th>Focal Length</th>
<th>Long Side (deg)</th>
<th>Short Side (deg)</th>
<th>Magnification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2032 mm</td>
<td>1.02° * 0.68°</td>
<td>(40 X)</td>
<td></td>
</tr>
<tr>
<td>1280 mm</td>
<td>1.62° * 1.08°</td>
<td>(26 X)</td>
<td></td>
</tr>
<tr>
<td>1270 mm</td>
<td>1.63° * 1.09°</td>
<td>(25 X)</td>
<td></td>
</tr>
<tr>
<td>800 mm</td>
<td>2.59° * 1.73°</td>
<td>(16 X)</td>
<td></td>
</tr>
<tr>
<td>500 mm</td>
<td>4.15° * 2.76°</td>
<td>(10 X)</td>
<td></td>
</tr>
<tr>
<td>300 mm</td>
<td>6.91° * 4.61°</td>
<td>( 6 X)</td>
<td></td>
</tr>
<tr>
<td>200 mm</td>
<td>10.3° * 6.91°</td>
<td>( 4 X)</td>
<td></td>
</tr>
<tr>
<td>135 mm</td>
<td>15.4° * 10.2°</td>
<td>(2.7X)</td>
<td></td>
</tr>
<tr>
<td>100 mm</td>
<td>20.7° * 13.8°</td>
<td>( 2 X)</td>
<td></td>
</tr>
</tbody>
</table>

Suggestions

- M51 – Whirlpool Galaxy
- M42 – Orion Nebula
- Rosette Nebula
- M31 – Andromeda Galaxy
- Veil Nebula
Subject Selection

Transparent sheet overlay
Used for framing subjects

Finders

6 x 30 Finder
(7 x 50 Finder inside)

Telrad Finder

35mm Field of View

8” Schmidt Cassegrain
- Prime focus @ f/10 - 1.02º x 0.68º
- Prime focus @ f/6.3 - 1.62º x 1.08º

5” Schmidt Cassegrain
- Prime focus @ f/10 - 1.63º x 1.09º
- Prime focus @ f/6.3 - 2.59º x 1.73º
Photo Through The Eyepiece

Mount camera & lens to look through telescope eyepiece
Aim at subject and carefully track the movement of the stars
Open the shutter for 1/1000 sec to 2 sec

Moon – Mare Humorium
Quartz Hill
135mm Lens @ f2.8
C8 @ f10 24mm Eyepiece
800 ASA Film
1/2 sec exposure
Gassendi
Photo Through The Eyepiece

Creative Freedom

- Composition – Limited Options
  - Field of View (Telescope Focal Length)
- Subjects
  - Moon / Planets

Equipment

- Telescope
- Tripod
- Camera

Problems

- Exposure – automatic settings may work
- Blurred image – tripod helps

Note – This works great with Video Cameras !!
Example Photos Through The Eyepiece

Moon – Mare Humorium

Quartz Hill

135mm Lens @ f2.8
C8 @ f10  24mm Eyepiece
800 ASA Film
1/2 sec exposure

Mersenius
Example Photos Through The Eyepiece

Moon – Mare Humorium
Quartz Hill
135mm Lens @ f2.8
C8 @ f10  24mm Eyepiece
800 ASA Film
1/2 sec exposure
Eyepiece Projection Photography

Mount camera body to look through telescope eyepiece
Aim at subject and carefully track the movement of the stars
Open the shutter for 1/1000 sec to 2 sec

Moon – Mare Humorium
Quartz Hill
C8 @ f 10
15mm lens @ 150mm
800 ASA Film
1/2 sec exposure
Eyepiece Projection Photography

Creative Freedom

• Composition – Limited Options
  • Field of View (Telescope Focal Length)

• Subjects
  • Moon / Planets

Equipment

• Telescope with equatorial mount
• Camera adapter
• Focus equipment
• Locking cable release
• Camera with ‘B’ setting
• Objective cover

Problems

• Exposure
• Blurred image – tripod helps
• Unsteady atmosphere can degrade image
• Focus is more critical
Eyepiece Projection Photography

Comment

This is VERY difficult

Not forgiving of focus errors
Even slightest vibration can ruin picture

Eyepiece Projection Focal Ratio

\[ \text{focal ratio} = \frac{f \times \text{dist to film}}{\text{eyepiece fl}} \]

\[ = \frac{10 \times 150}{15} = 100 \]

Focal length = 100 * 200 = 20,000 mm

Magnification = 20,000 / 50 = 400X
Example Eyepiece Projection Photos

Jupiter

Quartz Hill

C8 @ f 10
15mm lens @ 150mm

800 ASA Film
1/2 sec exposure

Digitally Enhanced
Example Eyepiece Projection Photos

Jupiter

Quartz Hill

C8 @ f 10
15mm lens @ 150mm

800 ASA Film
1/2 sec exposure

Original Image
Example Eyepiece Projection Photos

Saturn
Quartz Hill
C8 @ f 10
15mm lens @ 150mm
800 ASA Film
1 sec exposure
Moon – Sinus Iridum
Quartz Hill
C8 @ f10
15mm lens @ 150mm
800 ASA Film
1/2 sec exposure

Bianchini – 25 miles wide
Acknowledgments

Marie Allen – Patience and Understanding

Martin Gerhold & John Eakin – Scanning Photographs

Bill Ellison – Driving Van to Red Rock Canyon
The End