DEEP SPACE PHOTOGRAPHY
- a rough guide

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DEEP SPACE PHOTOGRAPHY
1. PRE-REQUISITES
   - Mount
   - Camera / Lens / Telescope
   - Guiding
   - Software

2. TAKING IMAGES

3. PROCESSING – the fun part!
   - Workflow
   - Example M31
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For *faint fuzzies* need long exposure times

- One long exposure?
- Multiple shorter exposures best
PRE-REQUISITES

Mount

- Multiple long exposures require an equatorial tracking mount and a sturdy tripod – no image rotation
  - Fork-type with wedge
**PRE-REQUISITES**

*Cameras*

- DSLR or Mirrorless
  - Remote Timer Required
  - In-built Filter Restricts Ha
  - Use in RAW Mode
    - 10 to 14 bits resolution gives 4000 to 16000 grey levels
    - JPEG is 8 bits (256 grey levels) and
    - In camera processing
**PRE-REQUISITES**

**Cameras**

- Dedicated Astro Camera
  - Colour or Monochrome
  - CCD or CMOS
  - Cooled Sensor $T \sim -25^\circ C$
  - Up to 16 Bit Images (65535 grey levels)

- Monochrome Camera
  - Filters Required
    - RGB
    - Narrow Band Imaging
  - Pixel Binning Option
    - $1 \times 1$: 36 pixels
    - $2 \times 2$: 9 pixels
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Lenses and Telescopes

- TELEPHOTO LENS (>200mm)
  - No Attachment Issues with DSLR’s
  - Good for Medium to Wider Field Views
  - Primes Best but Zooms OK
  - Aspherical Lens Construction Minimises Coma

- Instructive to compare modern digital sensors with traditional photographic film
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CCD/CMOS vs Film

- Orion: Horsehead and Flame Nebulae from Lowell Observatory
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DSLR & Telephoto Lens

Canon T5i with 200mm lens  ISO 1600 166 x 60s exposures
Sky Guider Pro
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Telescopes

- A whole topic in itself!
- All Suitable – Refractor, Reflector and Compound (SCT)
- Key Factor is Focal Length $\rightarrow$ FOV
  - Most designs have curved image fields
  - Flat field corrector desirable
  - For non-imaging Newtonians check back focus travel!
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Telescopes

- Optical Coupling Camera to Scope
  - Direct (Prime Focus) – Best for Deep Sky
    - Compression (Focal Reducer) - Wide Field
    - Afocal – Eyepiece + Camera and Lens
    - Eyepiece Projection – Eyepiece + Camera
    - Negative (Barlow)

Best Used for Planetary Imaging
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Telescopes

Attaching Scope to DLSR

- Refractor and Reflector
- SCT

Astro cameras generally attach by M48 adapter
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Autoguiding

- Guide Camera Corrects for Drift and Mount PE
- Not Necessary if
  - Accurate Polar Alignment and
  - Short Exposures ~2min
- Guiding Needed for Longer Exposures / Narrow FOV
  - Finder scope + Guide Camera for FL < 1400mm
  - Off-axis Guider for FL > 1400mm
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Useful Software

- FOV Calculator
- Cartes du Ciel
- CCD Calc
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Useful Software

- Guiding
  - PHD2

- Camera Control and Image Processing
  - Deep Sky Stacker
  - IRIS
  - GIMP
  - Nebulosity
  - Maxim DL
  - StarTools
  - Photoshop CS6 + Plug-ins

Freeware

Purchase
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At Last - Taking Images!

- Align and Calibrate Mount
- Focussing
  - DSLR Live View to Magnify Star Image
  - Bahtinov Mask

- Guiding
  - If Guiding, open PHD choose guide star and calibrate
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Taking Images: DSLR

- Manual Mode (Bulb)
- Set ISO (800 – 1600)
- Set RAW Mode (highest bit level)
- Set Exposure 1 – 2min unguided; 1 – 5+ min guided
- Set Number of Exposures – S/N \( \propto \sqrt{n} \)
  - Try For At Least 1hr Total Exposure
- Test Shot – Check Histogram
- Go!
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Taking Images: Astro Camera

- Parameters Set in Software
- Colour Camera: Set Exposures and Go
- Mono Camera + Filters
  - Colour - Red, Green, Blue
  - Possibility of LRGB Imaging – 4 Separate Exposures!

![Image 1](image1.png)  ![Image 2](image2.png)  ![Image 3](image3.png)

Brightness (Luminance)  Colour (Binned)
Deep Space Photography

LRGB vs RGB

2hr Total Exposure

<table>
<thead>
<tr>
<th>LRGB</th>
<th>RGB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lum 1hr 1x1</td>
<td>RGB 3x40min 1x1</td>
</tr>
<tr>
<td>RGB 1h 3x20min 2x2</td>
<td></td>
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- LRGB → x2 Luminance Signal
- x2 Colour Signal to Noise

DSLR and colour astro camera users can convert the colour image to greyscale to give a synthetic luminance channel.
Deep Space Photography

Taking Images

- Take Calibration Frames
  - Darks
  - Flats
  - Dark Flats

Darks – Hot Pixels

Flats – Optical Defects and Dust

Lens cap on. Same exposure settings

Same focus setting. Expose (50% saturation) to evenly illuminated surface
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Processing – Work Flow: DSLR

Raw Astro Frames → Subtract → Calibrated Raw Frames → De-Bayerise → Linear Colour

Dark etc Frames → Align and Stack →

Histogram stretch, Colour Balance → Gradient removal, Final Tweaks → Final Colour Image

Master Colour Image

Use as synthetic luminance → Convert RGB to Monochrome
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Processing – Work Flow: Mono

- Raw Astro Frames
- Dark etc Frames
- Subtract
- Calibrated Raw Frames
- Align and Stack
- Initial L, R, G, B Images
- Image Processing
- LRGB Combine
- Final Image
- RGB
- Colour Image +
- Luminance Image
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Processing Example – M31

- **EQUIPMENT**
  - QHY9M + RGB Filters
  - APM 107/700 Refractor
  - Finderscope Guiding
  - HEQ5 Pro Mount

- **EXPOSURES**
  - Luminance 15 x 5min
  - Red, Green, Blue 12 x 3min Binned 2x2
  - Darks, Flats, Dark Flats
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Colour

- Red
- Green
- Blue

Calibrate Re-size → Align & Stack → Colour Combine

All performed in Nebulosity

RGB Initial
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Colour

Initial Image – Dark and Red Bias
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Colour

Initial Image – Red Bias  Colour Balance  Digital Development

Output

Input

Screen Stretch

Minimum  Maximum

Update >>
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Colour

DDP Demo

- Nebulosity
- Maxim DL
- Photoshop
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Colour

Digital Development + Colour Balance
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Colour

Need to increase colour saturation

Remove gradient
Gradient and Colour Demo

- Maxim DL
- Photoshop
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Colour

Take a break!
Re-examine image
Adjust as necessary

Final Image
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Expect to get at least this result from DSLR or Colour Astro Camera
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Luminance

Raw Frames → Calibrate → Align / Stack → Good S/N? → Deconvolution

Original

Max Entropy
Lucy Richardson
Van Cittert
*Fat Tail*

Decon x5
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Luminance

Stacked & Deconvolved

Digital Development Processing

Output

Input

Stretched
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Luminance

Gradient Removal
Levels & Curves I

Take a break again!
Levels & Curves II
Selective Sharpening
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LRGB

Lum

Align Images

RGB

Combine in Photoshop – Luminosity Blending Mode
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LRGB

LRGB Demo

• Photoshop
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LRGB

Initial LRGB

Final Tweaking with Curves
Colour Saturation and Balance
Flatten Layers
Save as 16bit tiff for archiving
Save as 8bit jpeg for sharing
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LRGB

LRGB Tweaks Demo

• Photoshop
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Final Image
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Thanks For Listening

Have A Go

Practice Makes Perfect!

Many of my astro photos are on the MKAS website. I also have an album on Flickr:

https://www.flickr.com/gp/143090818@N03/x3hy54