The Art of Solar Astrophotography
Using Narrowband Imaging

Joe Matus
Huntsville, AL
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Overview

- About me
- Observing the Sun – Safely
- Creating Narrowband Solar Photos
- Equipment
- Software
- Technique
- Sample Images
About Me – a Brief Bio

• Mechanical engineer by training (RPI, Troy, NY)
  • Lived in Huntsville since 1987

• Employed by NASA/MSFC as Project Manager of a cubesat, NEA Scout, flying on SLS Artemis I

• Married to my wife, Kate, also a NASA engineer
  • 2 daughters, Mary 24, and Laura Beth 21

• Photography is my hobby and passion
  • Interested since I was very young, but really became serious around 2001 when introduced to digital cameras
    • Started with a simple 1.3 Megapixel point-and-shoot
    • Graduated quickly to more capable cameras

• Shoot mainly with Nikon professional gear
  • Use specialized camera gear for astrophotography

• Largely self-taught
  • Spent hundreds and hundreds of hours contributing /participating in various photo forums
  • Have shot over 150,000 images
  • Constantly learning new things

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About me – Photography Interests

• Began shooting digital images to record family events
  • Oldest daughter and wife became interested in ice skating

• Ice skating is pretty low light, and demands more capable equipment
  • Moved up to Nikon DSLR

• I found I enjoyed the challenge of low light shooting
  • Moved to more and more capable equipment

• Astrophotography is ultimate low light photography
  • Challenging to get high quality, detailed images
    • Exposures are on the scale of hours for many subjects

• Solar astrophotography is a specialized field of astrophotography
  • Became interested when I looked through a solar telescope being tested by the MSFC Heliophysics department
    • I was mesmerized by the view it afforded of the sun and its atmosphere
  • Interesting details are not readily visible to most observers
  • Requires a combination of specialized equipment and techniques
    • Present within narrow bands of the visible spectrum

• I do photography for artistic and visual satisfaction, science
  • My scientific knowledge is limited!

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Observing the Sun - Safely

- **Image projection**
  - Project an image directly onto a screen or the ground
  - Allows visualization of sunspots

- **Projected Image**
- **Screen**
- **Sun Shade**

Image from: https://www.bu.edu/astronomy/undergraduate/astronomy-department-facilities/astronomy-department-solar-telescope/
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Observing the Sun - Safely

• **Solar Filter**
  • Can be a film or glass filter
    • Allows visualization of sunspots, and some surface granulation

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Observing the Sun - Safely

• **Narrowband Filter**
  • Most-popular narrow band filter passes light with wavelength of 656.28 nanometers
    • Hydrogen-Alpha (H-alpha) emission band of the chromosphere
      • Chromosphere is an outer layer of the sun
      • Red part of visual light spectrum
  • Allows for visualization of great amount of chromosphere detail
    • Stuff that is on and around the solar disc
    • Cannot be seen by the methods discussed, above)
  • It is what I will cover in this presentation

Images in H-alpha look very red to the eye
Creating Narrowband Solar Photos

• **Narrowband (H-alpha) solar imaging requires**
  • Equipment
    • Telescope with H-alpha filter
    • Telescope mount
    • Camera
    • Computer and other
  • Software
    • Extensive processing is needed to get the best detail and quality
    • Various free and paid software programs help with that
  • Techniques
    • Equipment set-up
    • Image capture
    • Image processing
    • Image output

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Equipment

• H-alpha filters and scopes
• There are several popular manufacturers of H-alpha scopes and filters (and other solar products)
  • Coronado, Lunt, and Daystar
• I bought a solar telescope from Lunt
  • Model LS60THaP
    • 60 mm lens diameter
    • f/8.3 (making it about 500mm focal length)
  • H-alpha filter is integral part of the scope
    • It has a tuning knob to adjust air pressure within the filter to fine tune the transmission band and help isolate the solar features of interest
      • Filter is “pressure tuned”, as opposed to mechanically adjusted
      • Provides for more stable image adjustment
  • I augmented it with an additional (double stack) H-alpha filter to further narrow the transmission band and improve detail

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Equipment

• Solar Scope Overview

“Double Stack” Filter

Sun Finder

Eyepiece Holder

Pressure Tuning Knob

Tuning Wheel

H-alpha Filter (Etalon)

Diagonal with Blocking Filter
(Reduces energy reaching the eye)

Focus

Objective Lens

Convex Lens

Etalon

Concave Lens
Equipment

• A mount is needed to hold the scope and to allow the instrument to track the sun as it moves across the sky
• I use an Orion Altas Pro AZ/EQ-G to provide a stable imaging platform

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**Equipment**

- **Camera**
  - The image from the H-alpha scope is of a single wavelength (red), hence monochrome
    - Monochrome camera provides the most data
  - **ZWO ASI178MM-Cool**
    - Thermoelectrically cooled, monochrome astronomy camera
      - USB3, 6.4 megapixels (3096 x 2080)
      - Captures still images, or video @ 60 frames per second @ full resolution, faster with lower resolution
      - IMX178 1/1.8 CMOS sensor with 8.92mm diagonal
  - Mounted on the eyepiece holder (no eyepiece) allows capture of the full solar disk
  - Combined with Televue 2.5X powermate, (magnifier) can get close up surface details
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**Equipment**

- **Computer**
  - Standard PC laptop
    - Dell XPS 13” with i7 CPU and 16 GB RAM, Windows 10
  - Use for image data capture and image processing
  - Have large screen monitor at my desk

- **Other equipment**
  - Work table
  - Sun shade or umbrella
  - Car battery to power mount and camera
Software

• **Software is a key tool for producing images**
  • Needed for image capture, processing, finishing
  • Programs have generally been developed by enthusiasts (for PCs).

• **Programs and Applications**
  • SharpCap
    • Freeware that facilitates capture of still and video images, and camera control, including management of camera cooler
  • Autostakkert!
    • Freeware that facilitates combining multiple still frames, or video frames into a final, composite image
  • RegiStax
    • Freeware that has many capabilities, I use it for sharpening image features
  • Adobe Photoshop
    • My main, paid software tool for overall image processing and finishing

• **These are not all the available software options, but are the ones with which I am most familiar**
Technique

• **Workflow**
  • Consists of several main steps

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Technique – Equipment Setup

• Ideally, there will be nice clear, stable skies!
• Position the mount
  • Level and north-pointing axis (use a compass and a level)
  • Plug it into the battery
• Attach the scope and counterweights
• Attach the camera (and powermate) and balance the rig
• Attach the computer to the camera via the USB cable, and start SharpCap
• Point at the sun, center the image, and start tracking

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Technique – Image Capture

• Most important part of the process
• Capture still images, or video (which is really a series of still images)
  • Video will produce better results, and I prefer this method
• Video provides opportunity for “lucky imaging”
• Earth’s atmosphere is very turbulent, and images are degraded by the turbulence
  • Every once in a while, one gets “lucky” and there is a momentary clear image, or partial clear image
  • Want to capture “lucky moments”
• Video allows for many frames per second, increasing the chances of catching a lucky break and getting a clear image
  • Faster frame rates further increase chances of clear images
• Image processing will take advantage of this

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Technique – Image Capture

• While details on the solar disc and along its edge are easily seen with the eye via the H-alpha scope, it is difficult to capture details of each, at the same time via a camera
  • Features visible on the main part of the disc include sunspots and filaments
    • Chromospheric features at the limb, or edge, of the disc show prominently against the darkness of space
  • Prominences (or proms) show up mainly as wispy loops extending from the disc
    • They have very fine and faint detail compared with the surface
    • Have to generally capture prom details separately from surface, with two different exposures

• For the purpose of this presentation, I will use the term “surface” to refer to the details visible on the solar disc itself

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Technique — Image Capture

- **Important consideration for getting a good images**
  - Good seeing conditions
  - Good adjustment of the H-alpha filter and good image focus

- **SharpCap software used to control the camera and settings, and capture the images**
  - I use the zoom control in SharpCap to zoom in on the image
  - I adjust the exposure and gain to help see details

- **I adjust the solar scope filter tuning knob to get the most contrast in the solar features, in both surface details and proms**

- **Then I adjust the scope eyepiece focus until the sharpest image is present**
  - Takes some tweaking

![View of Zoomed Image](image1)
![Camera Controls](image2)
![Image from camera](image3)
![Typical SharpCap Screen Shot](image4)
## Technique – Image Capture

- **Typical image captures**
  - These are screen grabs from the RAW video

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### Exposed for surface, proms are not visible

- Surface Details in Light Areas are Well Exposed

### Exposed for proms, surface details lost

- Faint Proms and Edge Details are Very Visible
- Surface Details are Overexposed and Lost

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Technique – Image Processing

• **Lucky Imaging**
  • Autostakkert! software is used to comb through the video frames of each video to pull out frames of the best quality
  • Frames are then added (stacked) together into a final, composite image

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Technique – Image Processing

- Images are imported into RegiStax for Wavelet Sharpening
  - This routine provides great control over sharpening and helps pull out and emphasize detail

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Technique – Image Finishing

• Adobe Photoshop
• This is the step in the workflow where the real magic happens
  • The exact process will vary, depending on the photographer

1. Import images from previous step into Photoshop
2. Place on separate layers. I like to put the prom details on the top layer.
3. Align images to each other.

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Technique – Image Finishing

4. Go to each layer and enhance. Always try to preserve the highlights, and not blow out detail.

Use “Levels” or “Curves” to help increase contrast, sharpen using “Unsharp”. Try and coax out as much detail as possible.

I also may “invert” the surface layer, as it tends to accentuate detail.
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Technique – Image Finishing

6. Make the layer with the solar surface visible. It will be below the prom layer. It will fill in the hole created by the previous step.

7. Scale the layer up by a % or two, to ensure the hole is filled.

The image is nearly complete!
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Technique – Image Finishing

8. Go to each layer and colorize them to taste.

I use Image> Adjustment > Color Balance settings of:

<table>
<thead>
<tr>
<th>Shadows</th>
<th>R +23</th>
<th>G -12</th>
<th>B -90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midtones</td>
<td>R +51</td>
<td>G -39</td>
<td>B -85</td>
</tr>
<tr>
<td>Highlights</td>
<td>R +32</td>
<td>G -13</td>
<td>B -43</td>
</tr>
</tbody>
</table>

Saturation may need to be reduced on the layers to get the desired degree of colorization.

9. Finish by cropping and saving the image!
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Technique – Image Finishing

• The final product!

6/25/2017
Conclusion

• Thank you for being a part of this presentation!
  • I hope you enjoyed it, and it provided you with useful information.

• This was a brief overview of how I produce narrowband images of our star.

• Narrowband imaging takes some specialized equipment, but can be very rewarding.
  • The basics of image capture and processing, however, can be applied with more common equipment to images of the moon, planets, and other objects.

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Sample Images

• The Great American Eclipse 8/21/2017

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Sample Images

- See more at: https://jalan.smugmug.com/Astrophotography