Challenges of Imaging Jupiter 2008

Larry Owens

Why is Jupiter such a challenge?

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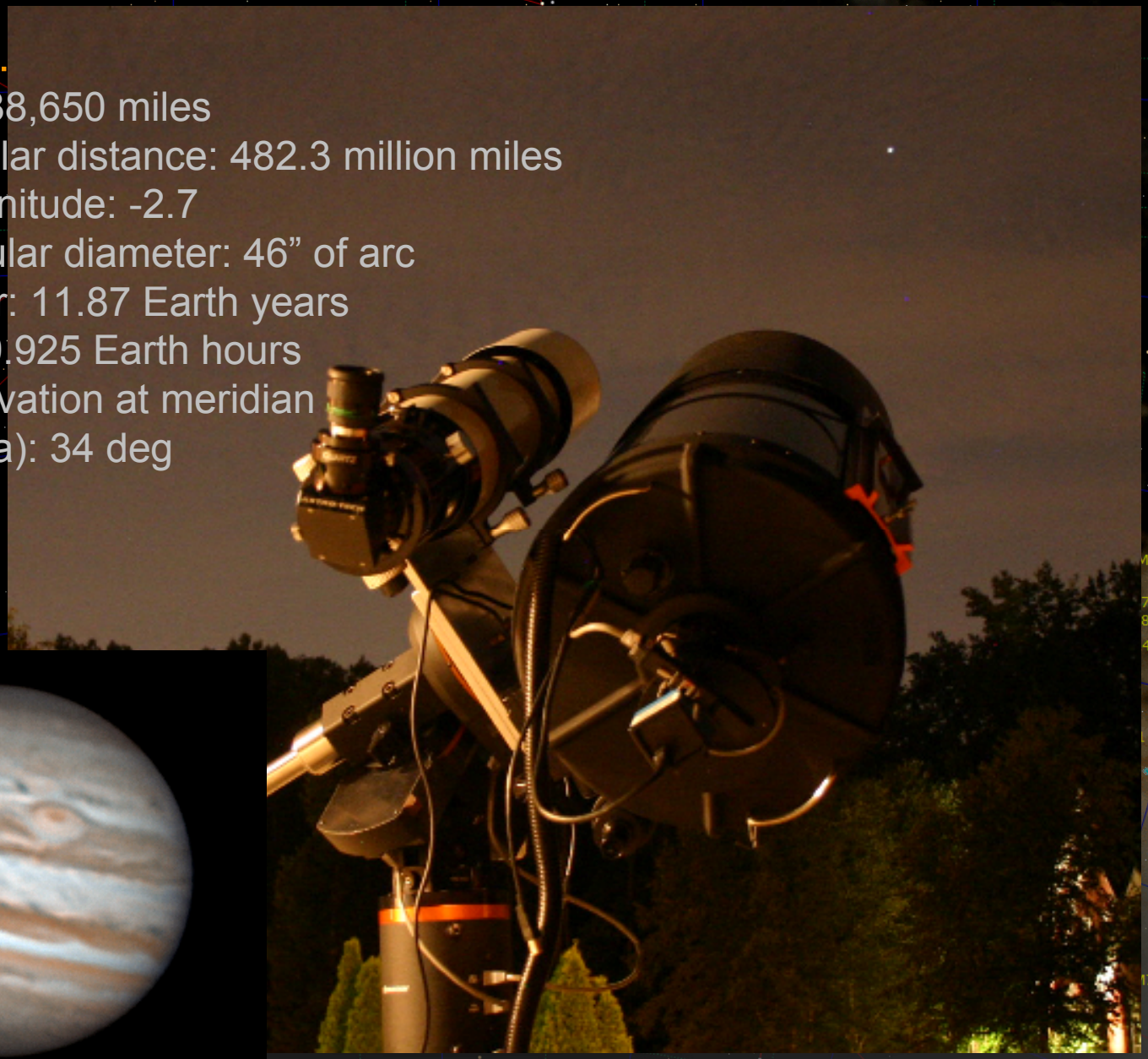
- Jupiter Stats…
  - Diameter: 88,650 miles
  - Average solar distance: 482.3 million miles
  - Visual magnitude: -2.7
  - Visual angular diameter: 46” of arc
  - Jupiter year: 11.87 Earth years
  - Rotation: 9.925 Earth hours
  - Current elevation at meridian (from Altanta): 34 deg



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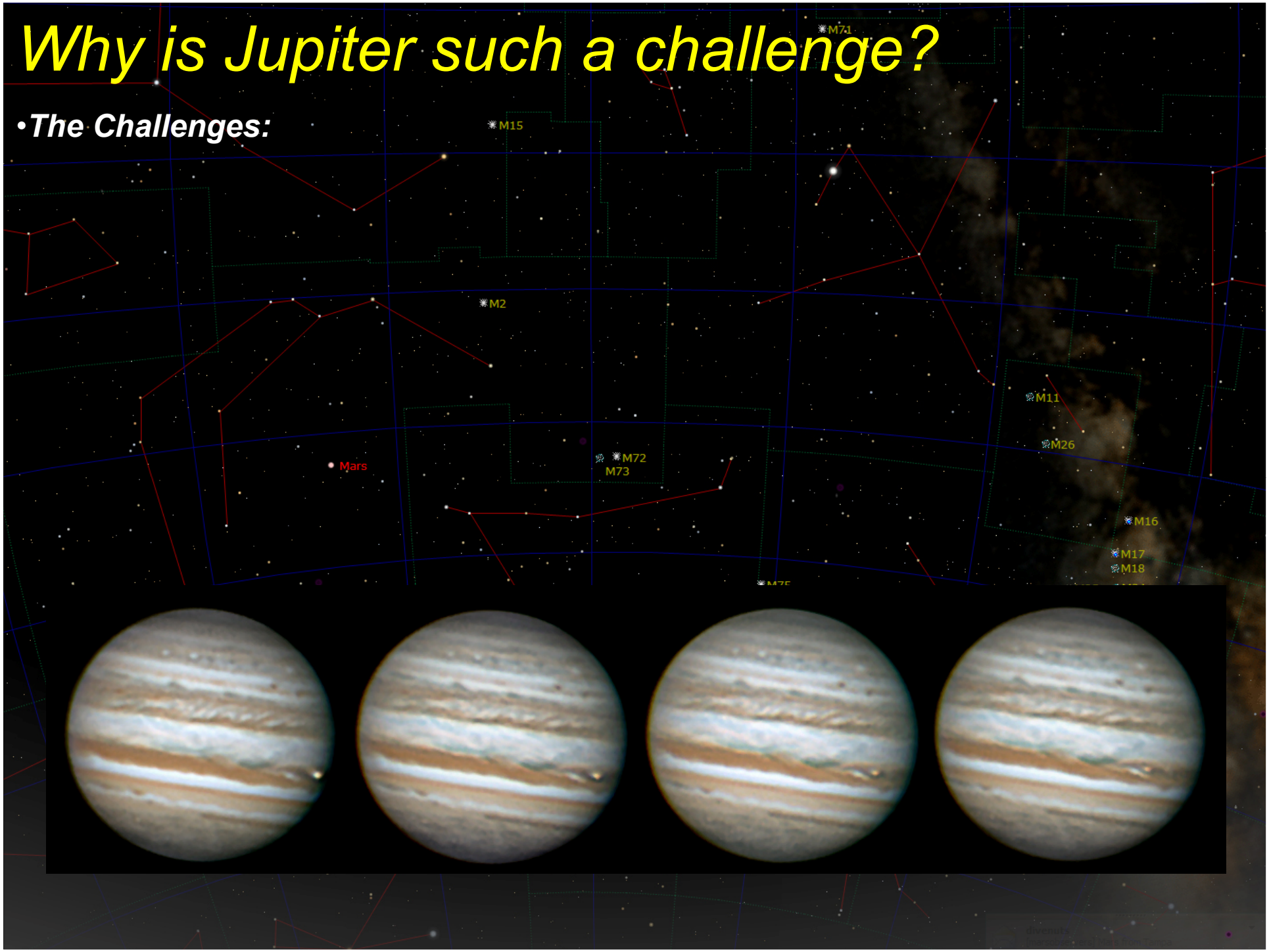
Even the Hubble has trouble with Jupiter

Note the color fringing in the lower left…

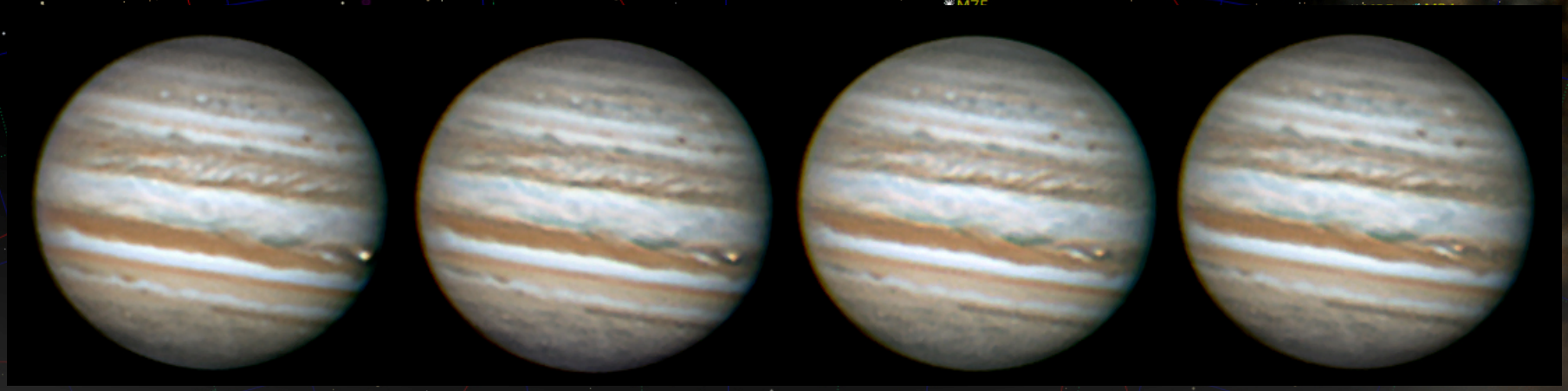
Why is Jupiter such a challenge?

- ***The Challenges:***



Why is Jupiter such a challenge?

- ***The Challenges:***
  - *Planetary rotation is a major challenge*
    - *Most planetary cameras require hundreds of frames for good images*
    - *Features will rotate significantly before reaching optimum frame count*
      - *RGB imaging with monochrome cameras is 3x as difficult!*
      - *Changing filters can be hectic*
      - *Some cameras induce noise at high frame rates*



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      - *Changing filters can be hectic*
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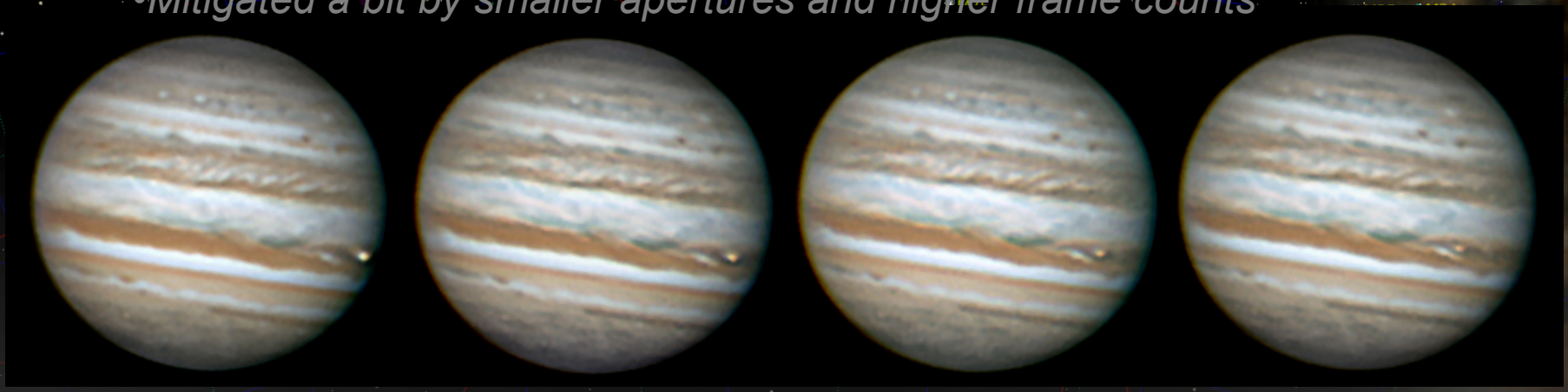
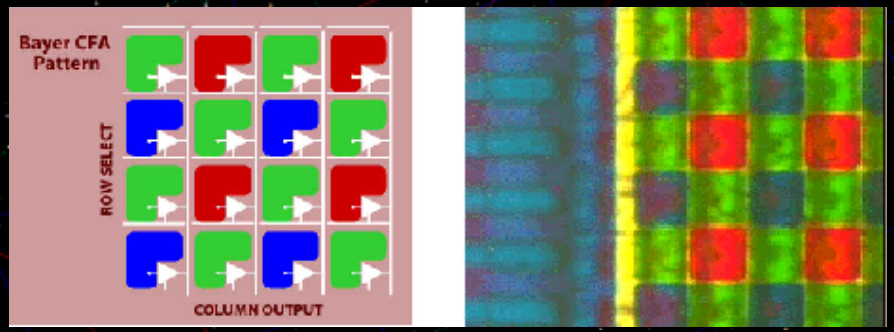
  - *Low altitude imaging significantly worsens atmospheric turbulence*
    - *Significantly softens detail*
    - *Local sources of turbulence become a problem (roof, heat sources)*
    - *Mitigated a bit by smaller apertures and higher frame counts*



Advantages of Color and Monochrome Cameras



Advantages of Color and Monochrome Cameras

- Color Cameras
  - Takes all 3 colors at once
  - Images are easier to acquire (no filter changes)
  - Easier to process (process only one avi)
  - **Why bother with a monochrome camera in the first place?**

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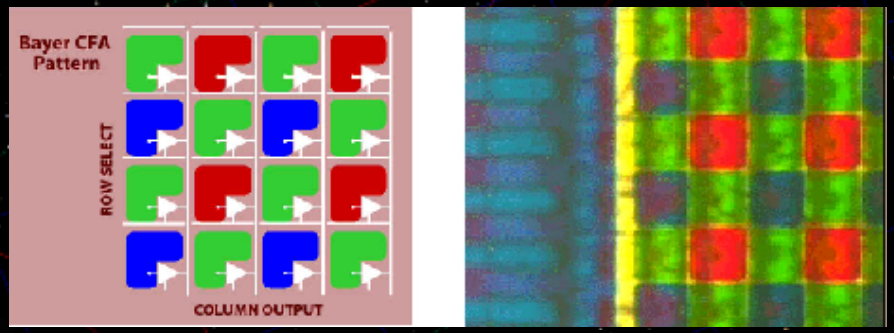

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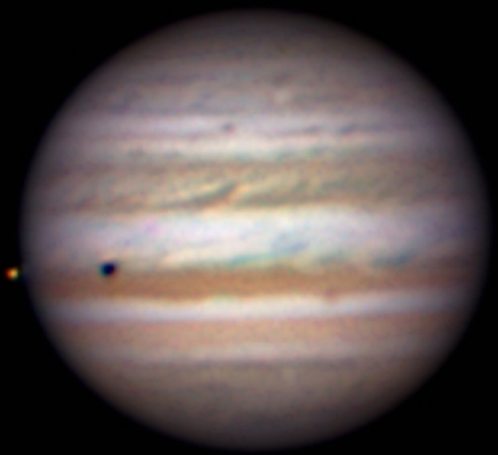
  - **Why bother with a monochrome camera in the first place?**
  - **Answer: The Bayer matrix and the De-bayer process of color cameras coupled with image enhancement resonances usually produce images with far less detail.**

Jupiter and Europa
7-25-08 at 0308 UT. D = 47", I = 326, II =199, III = 194

12" LX200 at f/20, DBK Colorcam - 2100 frames, 30 fps. Seeing - poor to fair 4 (10), Transparency - 5(10). GRS is on the limb. Richard Jakiel, Douglasville, GA

Jupiter and Io
7-31-08 at 0324 UT. D = 46.6", I =203.8, II = 30.5, III = 27.7



12" LX200 at f/20, DMK 21AF04.AS - RGB, CS filters. Seeing - good 5 (10). Transparency -hazy skies - 5(10). Richard Jakiel, Douglasville, GA.

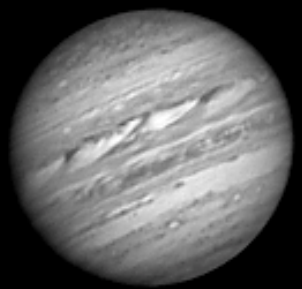
Advantages of Color and Monochrome Cameras

- Monochrome Cameras
  - Can use a variety of methods to get more detail
  - Filtered monochrome images are valuable to professionals
  - **Why bother with a color camera?**

02:10UT
CM: I-141.4 II-22.6 III-176.6

Jupiter 06/30/06, 02:10-02:25UT
Stability 5-7/10, Transparency 3/10 from Alpharetta, GA
C14@F/28, Lumenera Lu075M Monochrome CCD camera. Filters:
IR(700-980nm), RED(612-670nm), GREEN(488-574nm), BLUE(392-508nm)

Larry Owens planetographer@CFastronomy.org



IR 02:10UT
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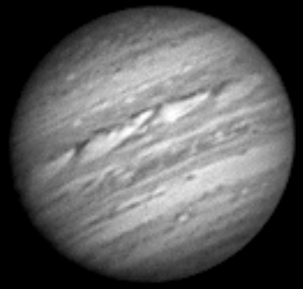
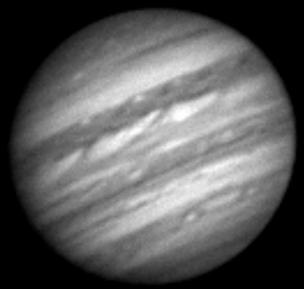
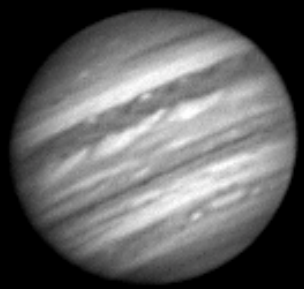


RED 02:17UT
CM: I-145.7 II-26.8 III-180.8



GREEN 02:21UT
CM: I-148.1 II-29.2 III-183.2



BLUE 02:25UT
CM: I-150.5 II-31.6 III-185.6

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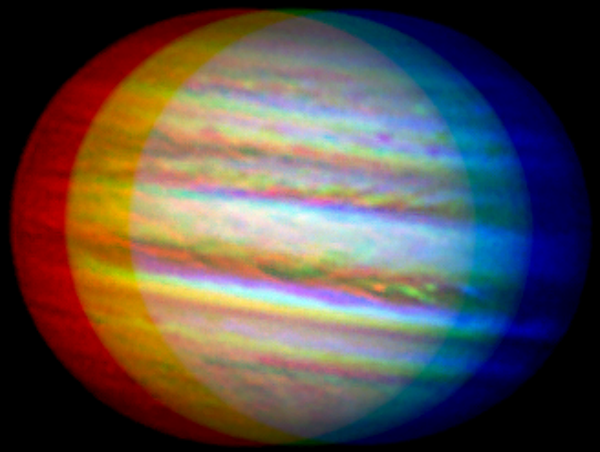

- **The process can get rather hectic**
  - 3 times the work in the same amount of time
    - Take 3 avi's
    - Changing filters
    - Refocusing (if necessary)
  - Processing takes 3 times longer
    - Stack 3 avi's
    - Process 3 images
    - Plus color combining and color correcting – time consuming
      - Kind of like adjusting the internal color controls of a TV

Monochrome Cameras and Jupiter

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- Frame Counts and Time Limits
  - Frame Counts
    - 1000-3000 per filter – DMK and Lumenera (Skynyx)
    - Fewer frames - less detail, grainy
    - More frames, more detail – to a point
      - Better chance of more “good” frames

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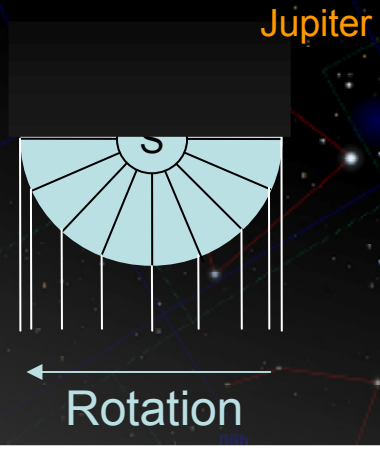
    - Remember Jupiter's day is only 9.9 hours!
    - The limit differs by frame alignment method
      - Align frames by entire planet
        - Time limit generally 2 minutes total (3 colors)



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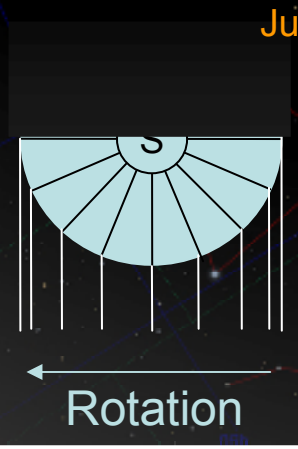
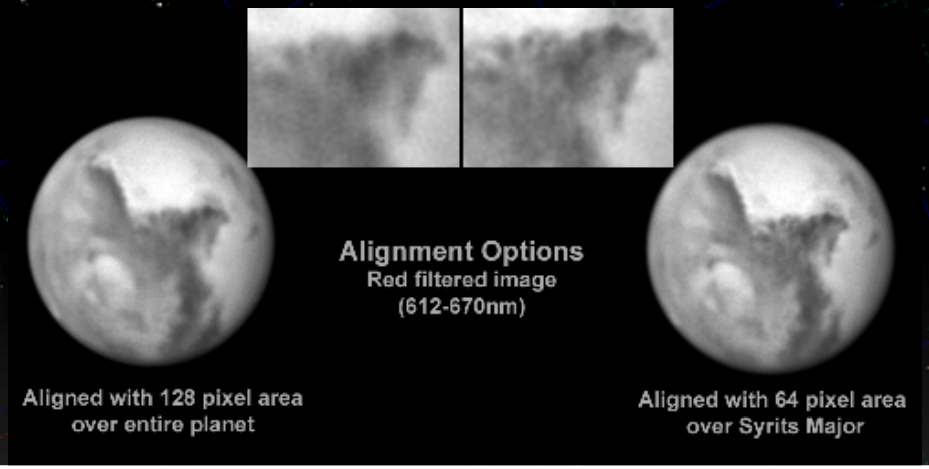
      - Align frames by feature (clouds, GRS, etc)
        - Typically 3 minutes total





Monochrome Cameras and Jupiter

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  - 2 minutes or 3 minutes (align by feature)

- **Example 1:**
  - 2000 frames per filter @ 30fps
    - RED – 67 sec
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    - Total: 3 min, 21 sec (Probably too long – 0 time to change filters)

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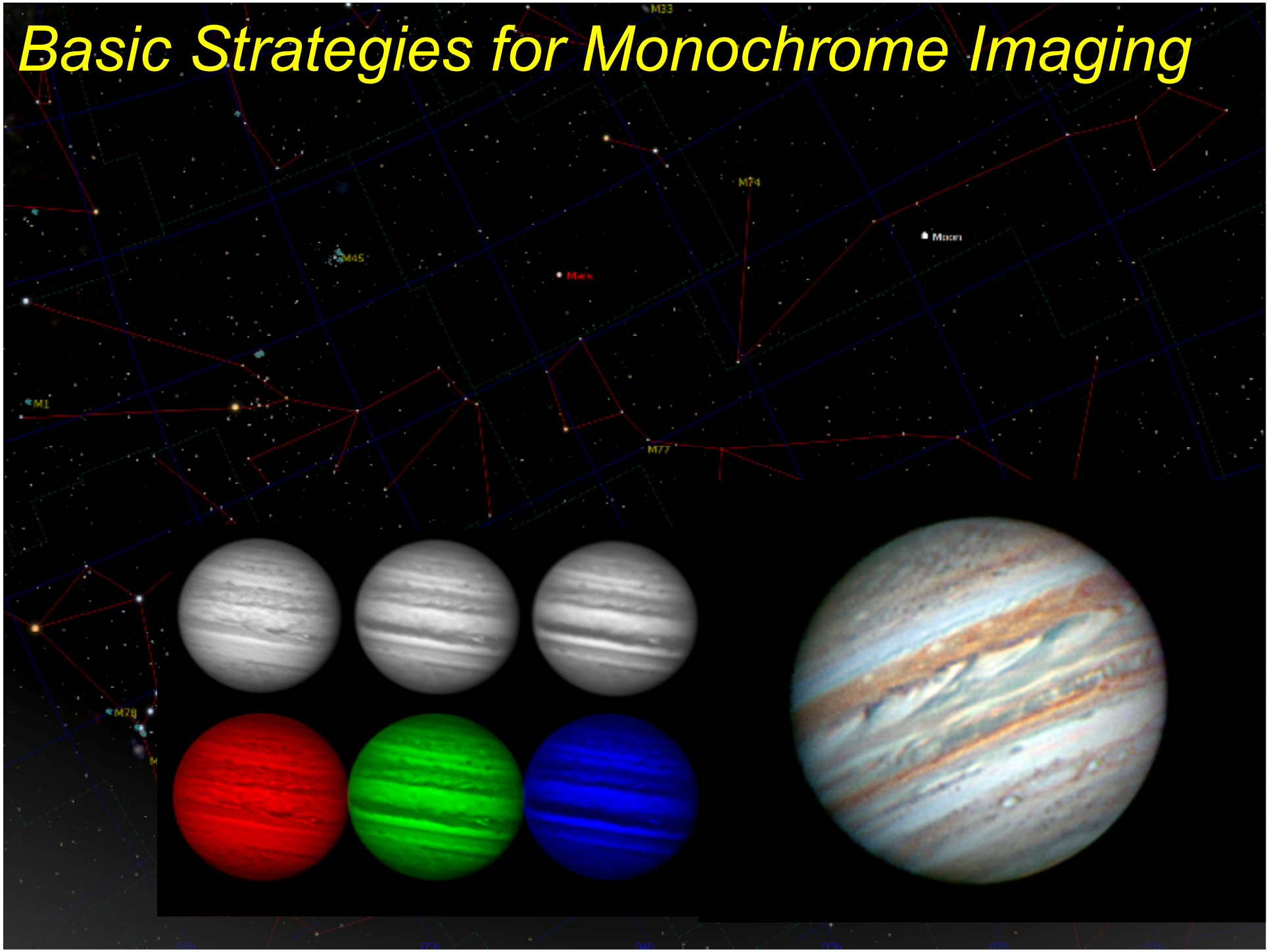
- **Example 3:**
  - Use synthetic GREEN – take only RED and BLUE filtered images
    - More later…

Basic Strategies for Monochrome Imaging



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- RGB (Red Green Blue)
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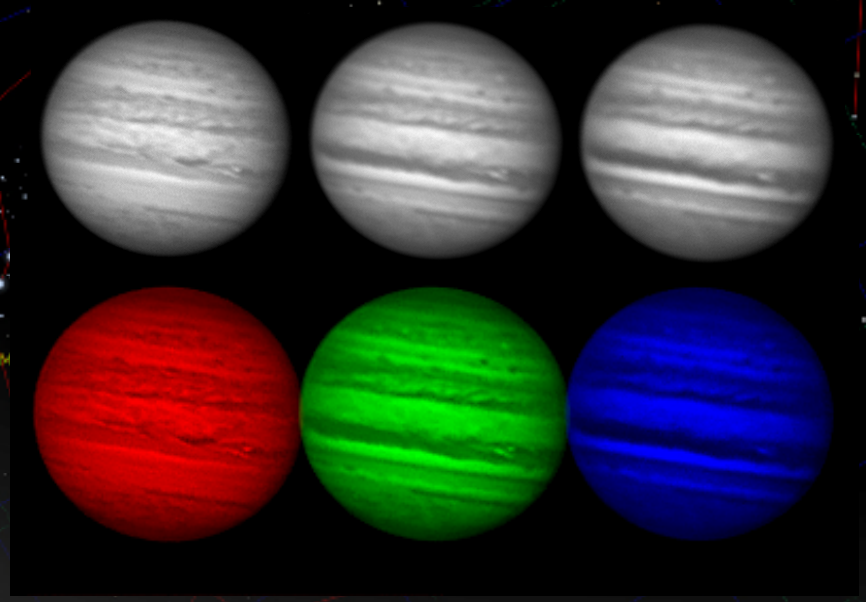

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- RGB (Red Green Blue)
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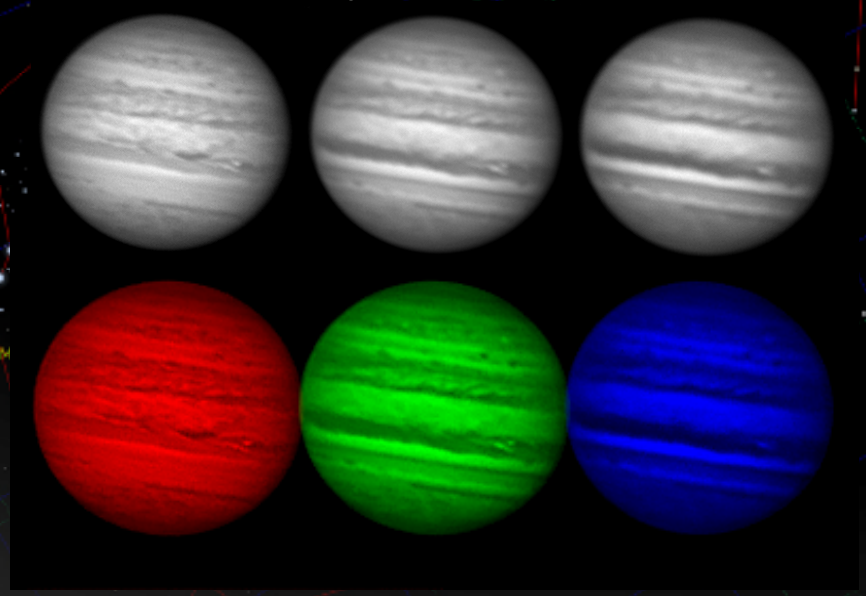
  - Processing
    - Stack and process 3 monochrome images
    - Color combine in PhotoShop
      - Each stacked image goes into a color channel
      - Result is an RGB color image of Jupiter



Basic Strategies for Monochrome Imaging

- R(G)B (Red (Green) Blue) – Synthetic Green
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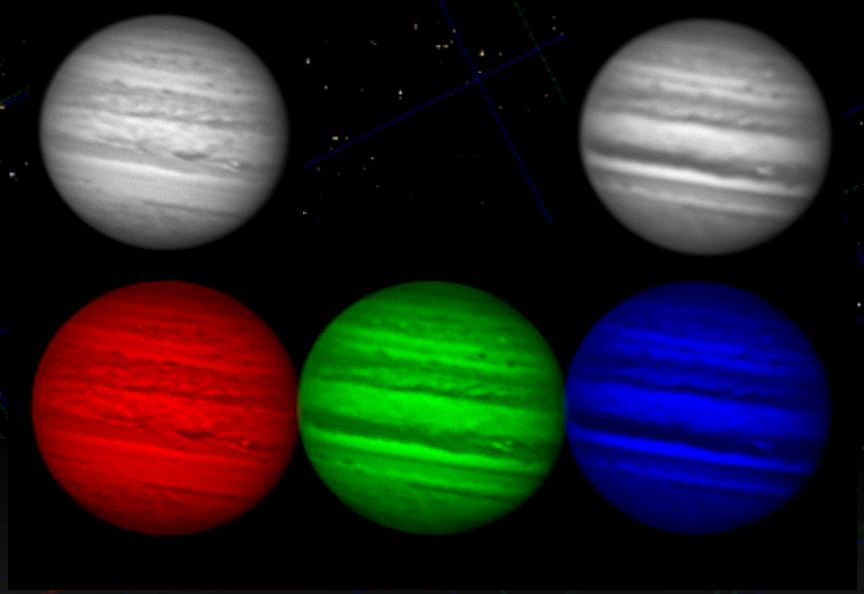

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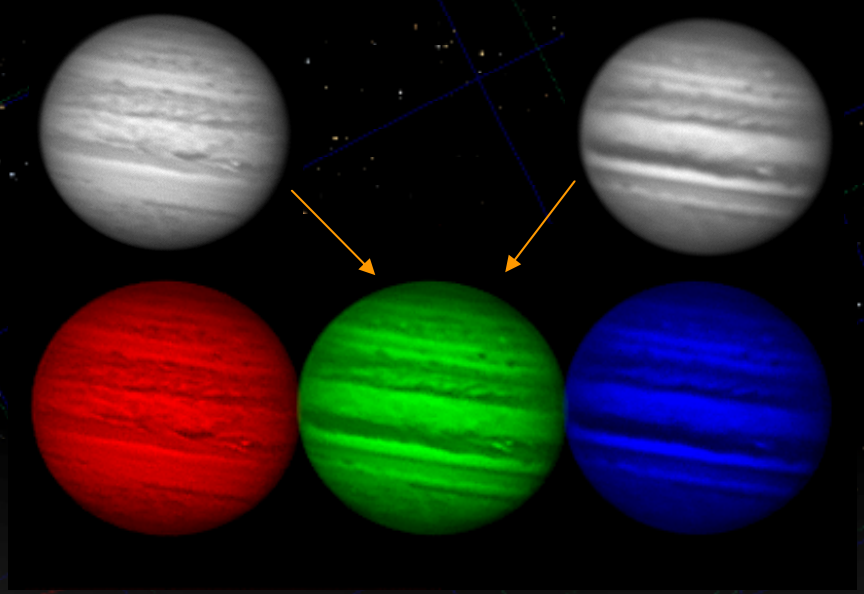

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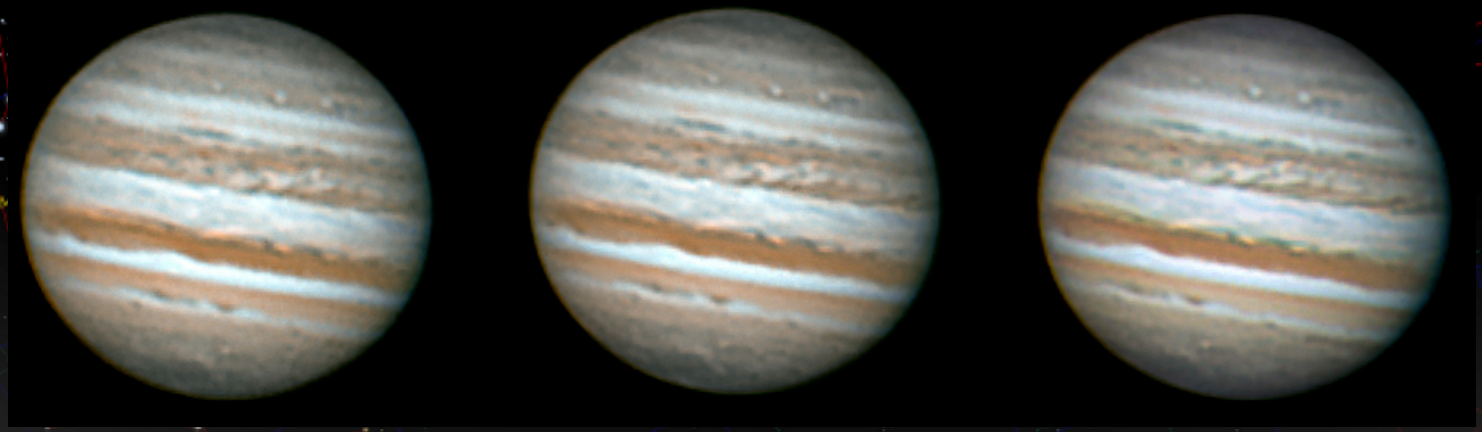
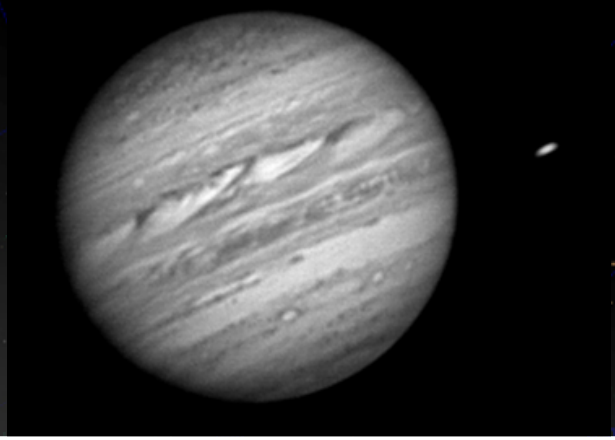
  - Images below are a mix of RGB and R(G)B. Can you tell which is which?



Basic Strategies for Monochrome Imaging

- LRGB (Luminance Red Green Blue)
  - Acquisition
    - Take 3 or 4 avi's, one through RED, GREEN and BLUE, plus Luminance
    - Luminance: GREEN or broad spectrum image (clear IR/blocked)
    - Using RED or IR for Luminance
      - Colors can be unrealistic
      - IR can provide amazing detail in bad conditions though
    - Advantages
      - Increase in detail, less color fringing



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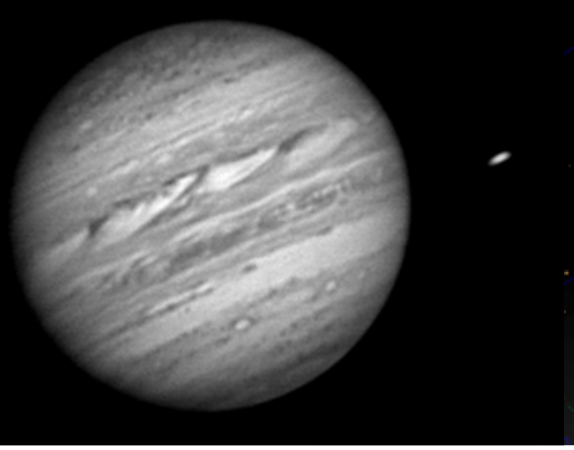

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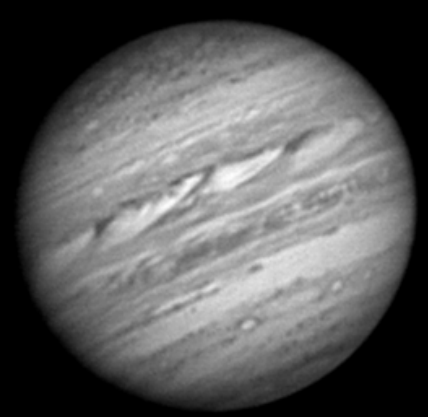

Equipment…

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- New to planetary imaging?
  - Buy the right tools for the job… instead of adapting the tools you have

    - Native long focus optics
      - Schmidt Cassegrain – Celestron/Meade, 9.25-16”
      - Maksutov
      - Long focus larger aperture refractors
    - Equatorial mount – CPC with wedge, German Equatorial (CGE, Losmandy)
    - Imaging Source DMK21AU04
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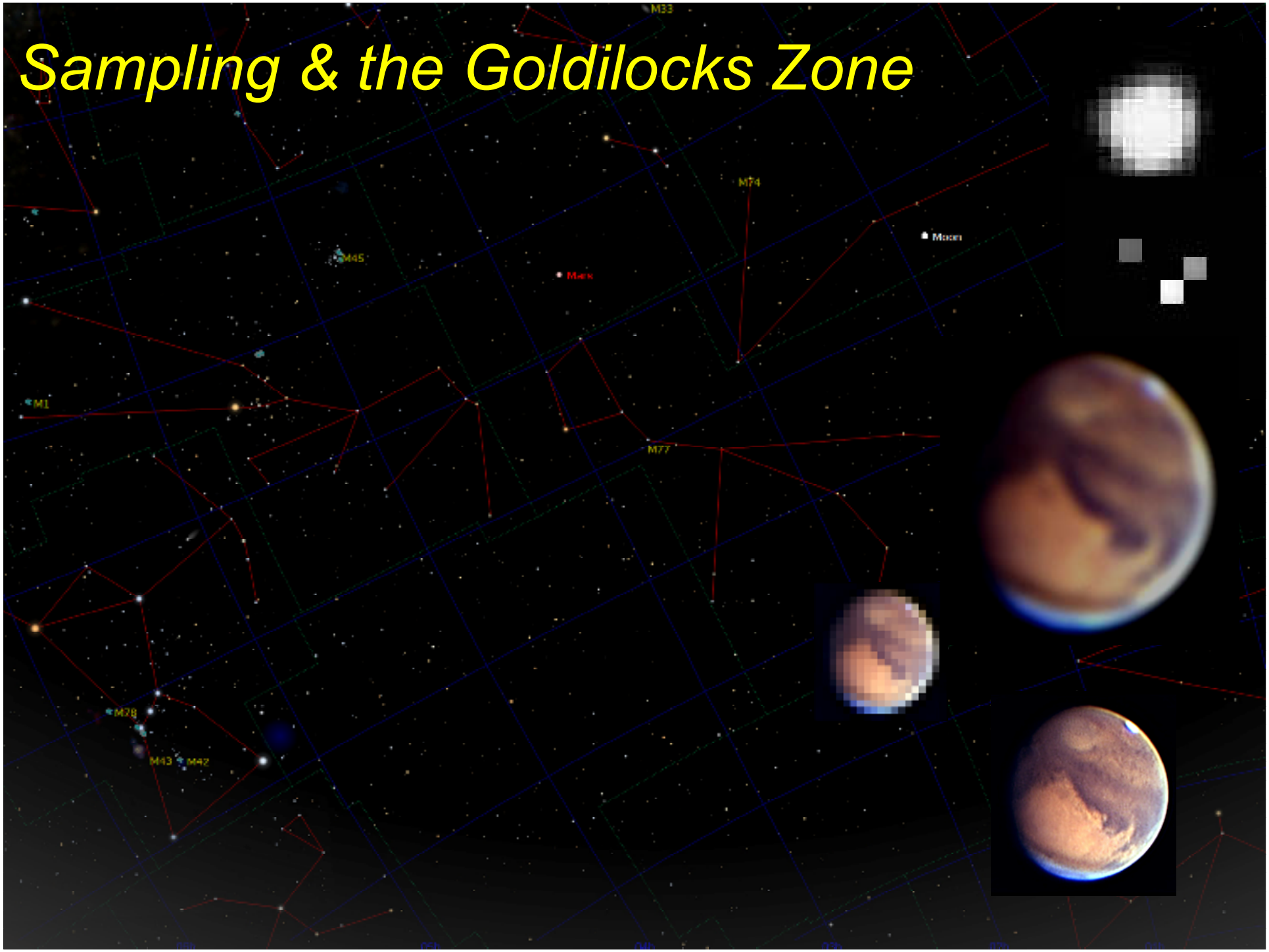
  - Motorized Focuser (probably more important than you think)
  - Motorized Filter Wheel (nice to have)
  - Parfocal Dichroic RGB filter set
    - Custom Scientific, Astrodon, others – don’t use visual filters
  - IR (infrared) blocking clear filter (not necessary)
  - IR (infrared) pass filter (nice to have)

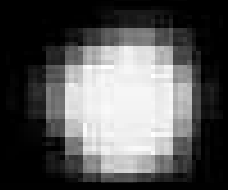
Sampling & the Goldilocks Zone

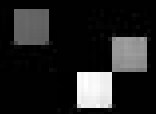


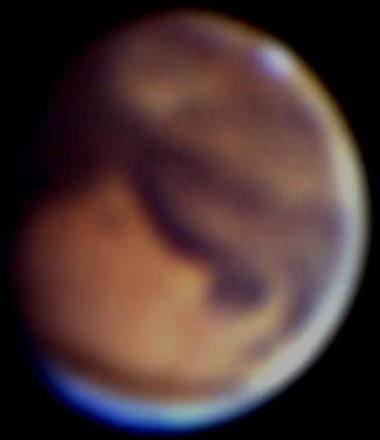
Sampling & the Goldilocks Zone

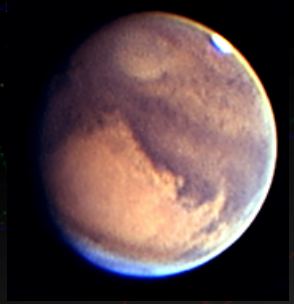
- Resolution is **not** the important setting

- Sampling is really what matters
  - Correct sampling captures the full resolution of the scope (or conditions)
  - Provides adequate light levels for sensible gain settings
  - *The best images are not possible unless sampling is right*









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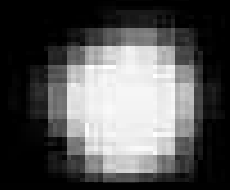
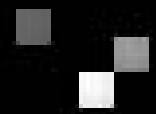
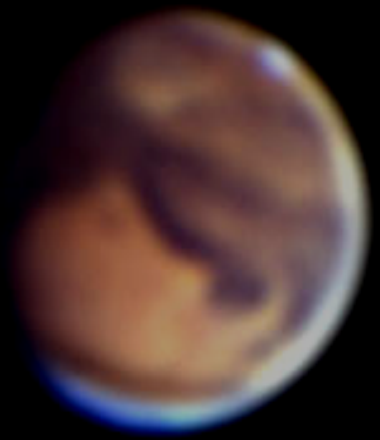
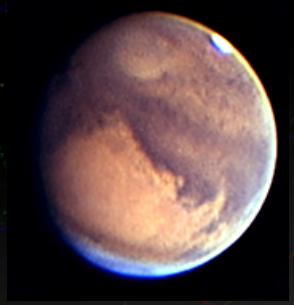
  - Power is too high, brightness too low
  - Requires longer exposure times
  - Very long exposures can cause loss of detail









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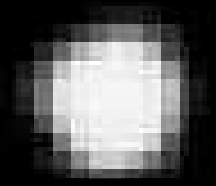
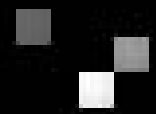
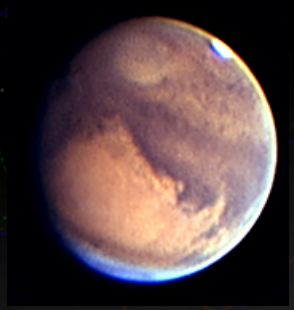
- Undersampling (not enough pixels)
  - Resolution of optics is wasted
  - Not enough pixels to represent finest details

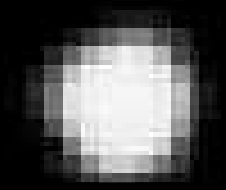




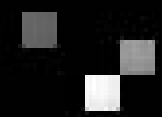


Sampling & the Goldilocks Zone

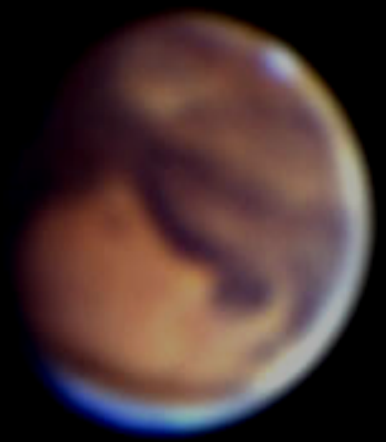
- Resolution is **not** the important setting



- Sampling is really what matters
  - Correct sampling captures the full resolution of the scope (or conditions)
  - Provides adequate light levels for sensible gain settings
  - *The best images are not possible unless sampling is right*

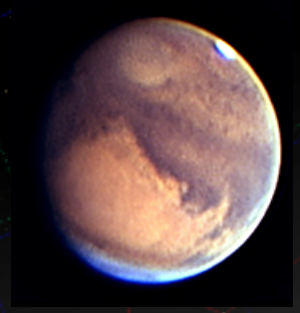


- Oversampling (too many pixels)
  - Power is too high, brightness too low
  - Requires longer exposure times
  - Very long exposures can cause loss of detail



- Undersampling (not enough pixels)
  - Resolution of optics is wasted
  - Not enough pixels to represent finest details

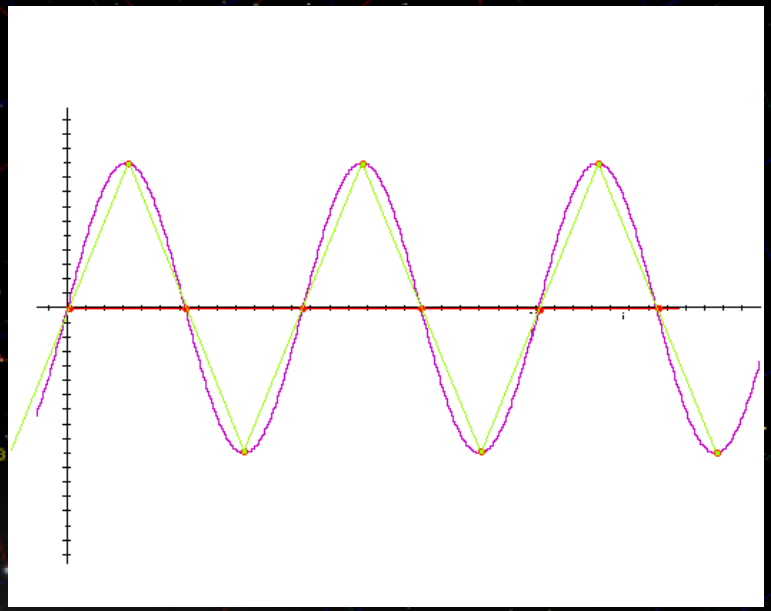
- Correct Sampling
  - Records all that is possible from optics and seeing conditions
  - Reasonable exposure times and gain settings
  - May need to undersample a bit – seeing, camera sensitivity

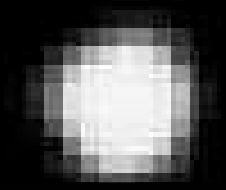


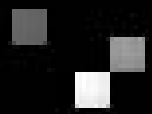
Sampling & the Goldilocks Zone

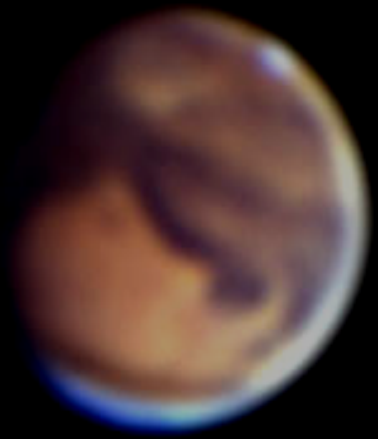
- Resolution is **not** the important setting

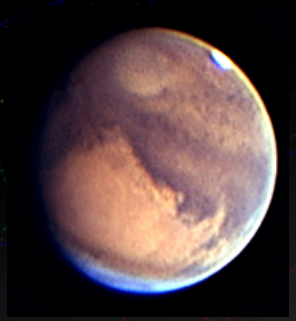
- Sampling is really what matters
  - Nyquist sampling rule – 2 to 3 pixels across the finest details
  - Considering atmosphere, Dawes limit can be a good rule of thumb
  - *Use 2 pixels across your scope's Dawes limit for sampling*
  - *Should be adjusted based on atmospheric conditions*











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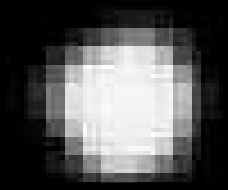

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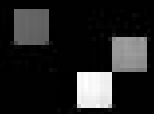
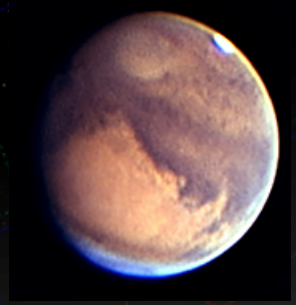
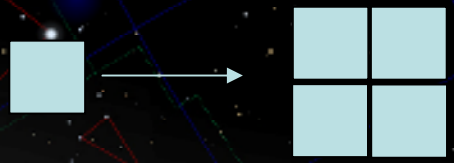


- Binning to change the sampling
  - Combines pixels to form LARGER pixels
  - Binning 2x2 changes 640x480 with 5.6μ pixels to 320x240 11.2μ
  - *Must use higher magnification*
    - Could solve Oversampling issues
    - Planet may not fit on the chip with smaller CCD's



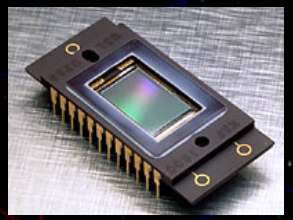


Sampling & the Goldilocks Zone

- Dawes Limits: (116/aperture in mm)

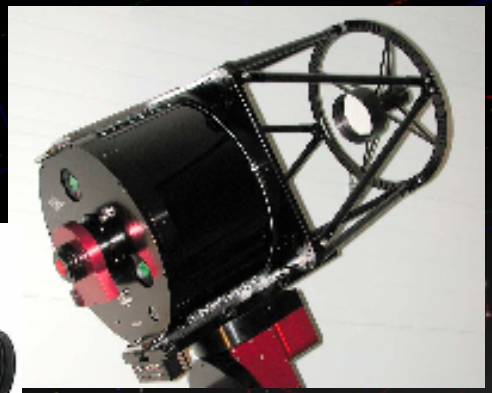
4” - 1.14”	11” - .41”
8” - .57”	14” - .33”
10” - .46”	16” - .29”

Pixel Sizes:
ICX098BL – 5.6μ (Toucam, DMK)
KAF402 – 9μ (ST-402ME, ST-7E)
TC-237 – 7.4μ (ST-237)
ICX424 – 7.4μ (Lumenera & other 1/3” Cams)

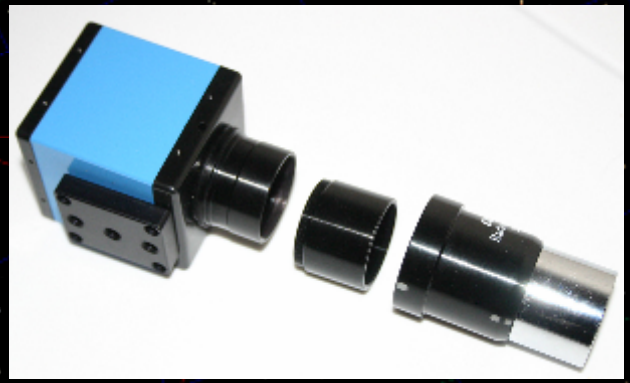


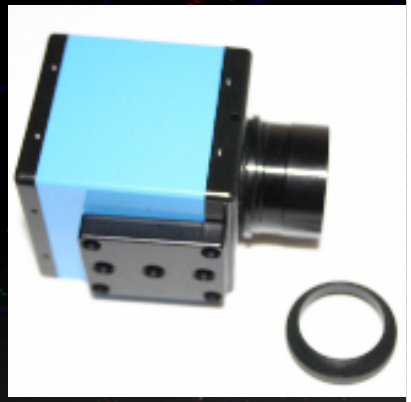
- Two ways to find arc seconds per pixel:
  - Arcseconds per pixel = $\frac{\text{(Pixel Size in microns)206}}{\text{Focal length in mm}}$ ***(Must know exact FL)***
  - Arcseconds per pixel = $\frac{\text{Size in arcseconds of known object}}{\text{Number of pixels across known object}}$ ***(Must know angular size of Planet)***

- Now you can find your exact focal length:
  - Focal length = $\frac{\text{(Pixel Size in microns)206}}{\text{Arcseconds per pixel}}$



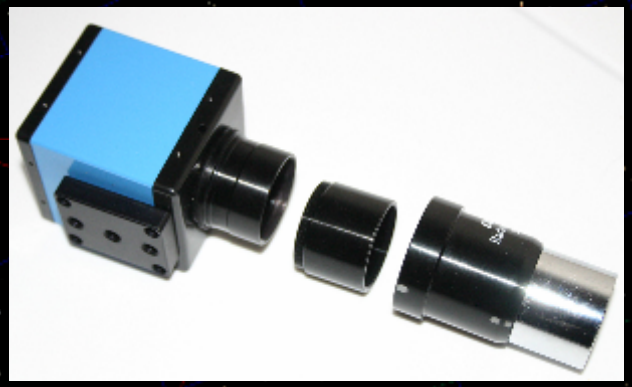
Getting Creative with Barlows and Extensions

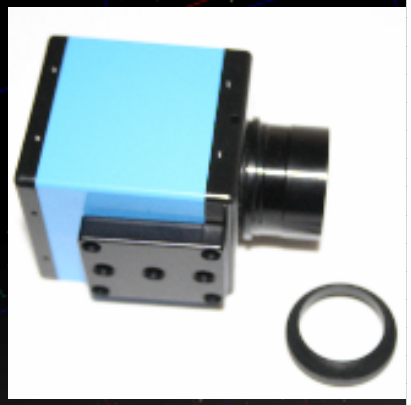




Getting Creative with Barlows and Extensions

- Take your barlow apart!
  - A great way to adjust your sampling





Getting Creative with Barlows and Extensions

- Take your barlow apart!
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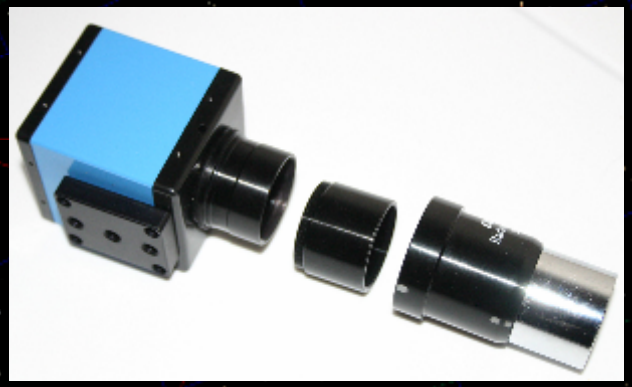
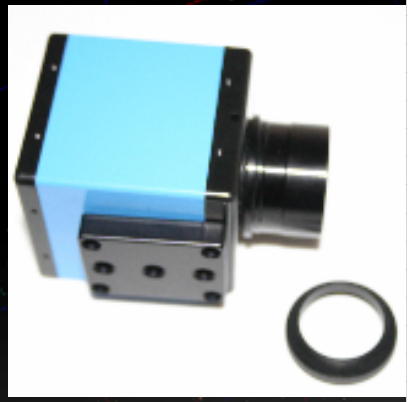
- Any barlow can provide a range of magnifications
  - 1.5x 2x 5x
  - Farther from screen – image is bigger, dimmer
  - Closer to screen – image is smaller, brighter





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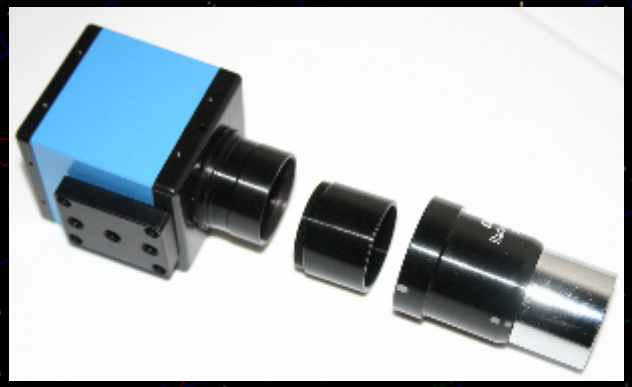
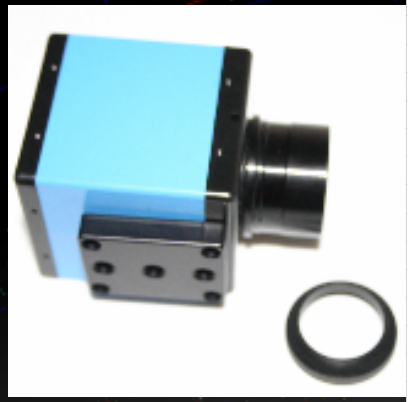
  - Lower power lens
  - Better suited to wider range of powers





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- Barlows with ***longer tubes***
  - Lower power lens
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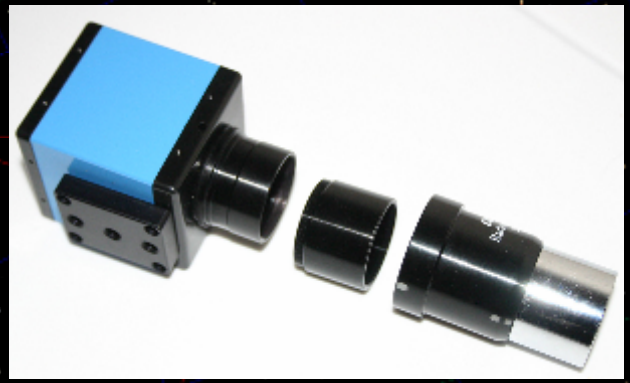
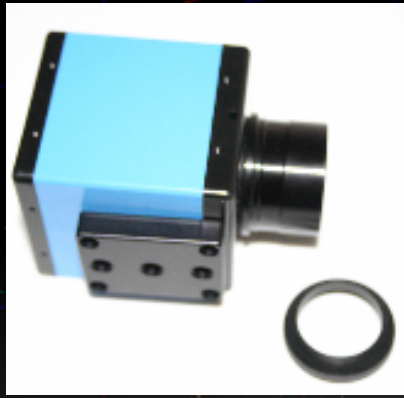
- Over sampling?
  - Move the barlow lens closer to the camera
  - Drop the lens into an extension, or…
  - Screw the barlow lens to the nosepiece

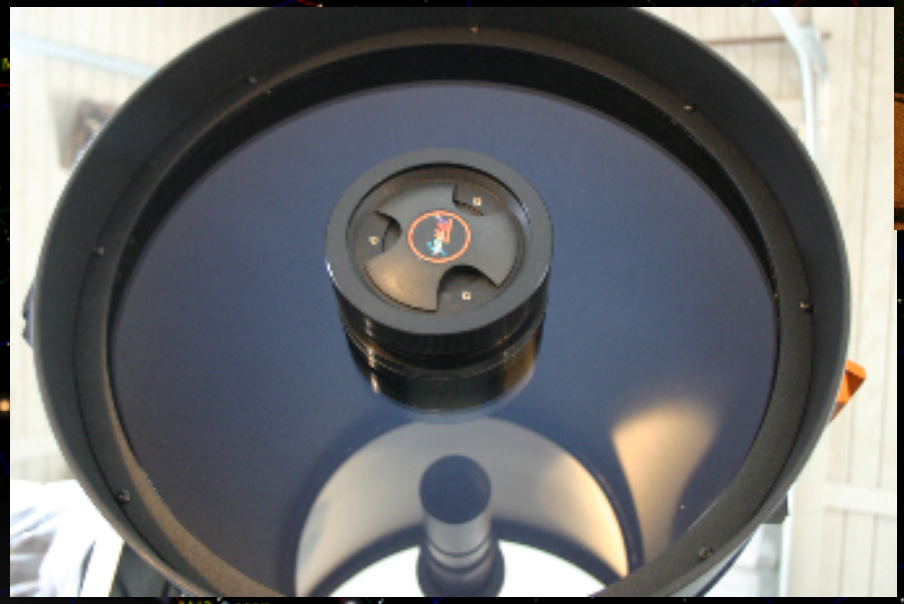




Getting Creative with Barlows and Extensions

- Eyepiece Projection
  - Typically for Newtonians
  - Very high powers from short focus scopes
- Use different eyepieces to vary sampling
- Adapters are easy to find
  - “C” thread to “T” thread

General Acquisition Guidelines



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- Getting the planet on the chip
  - Chips on most cameras are ¼” or 1/3”
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  - Take Jupiter out of focus
    - The out of focus light from the planet is very large by comparison
    - Makes it easier to find and center
    - Camera settings:
      - Turn “gain” all the way up
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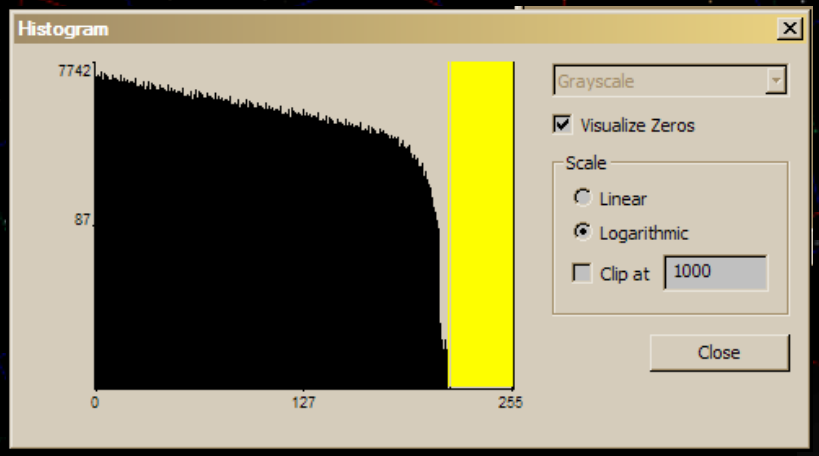
  - Center the planet with a low power eyepiece visually
    - Then with a higher power
    - Replace the eyepiece with the camera

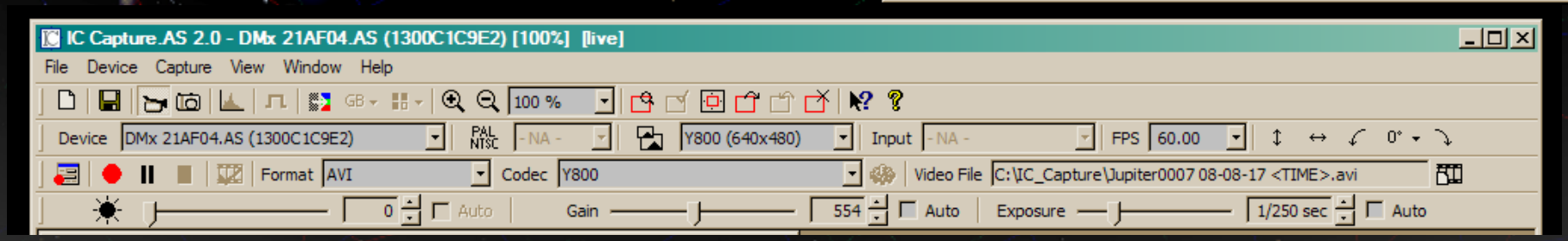
General Acquisition Guidelines

- Collimation
  - Extremely important
    - Take the time to learn when the scope is out of collimation
    - Learn how to collimate
    - Check the collimation periodically
      - How frequently depends on the scope
      - Also depends on how it's handled
      - Good idea to check it after traveling to a dark site

General Acquisition Guidelines

- Acquisition Session
  - IC Capture
    - Set input and output codec to Y800
    - Set format to AVI
    - Set filename header and sequence index
      - ALWAYS include date and time in filename
    - Always open the Histogram graph
      - A bit of yellow indicates image is not too bright
      - Plus, you're getting full tonal quality
    - Set a ROI (region of interest)
      - Very important with large frame counts
  - Place your focus control next to computer
  - Place your filter wheel control conveniently





Monitor Calibration & Standard Candles

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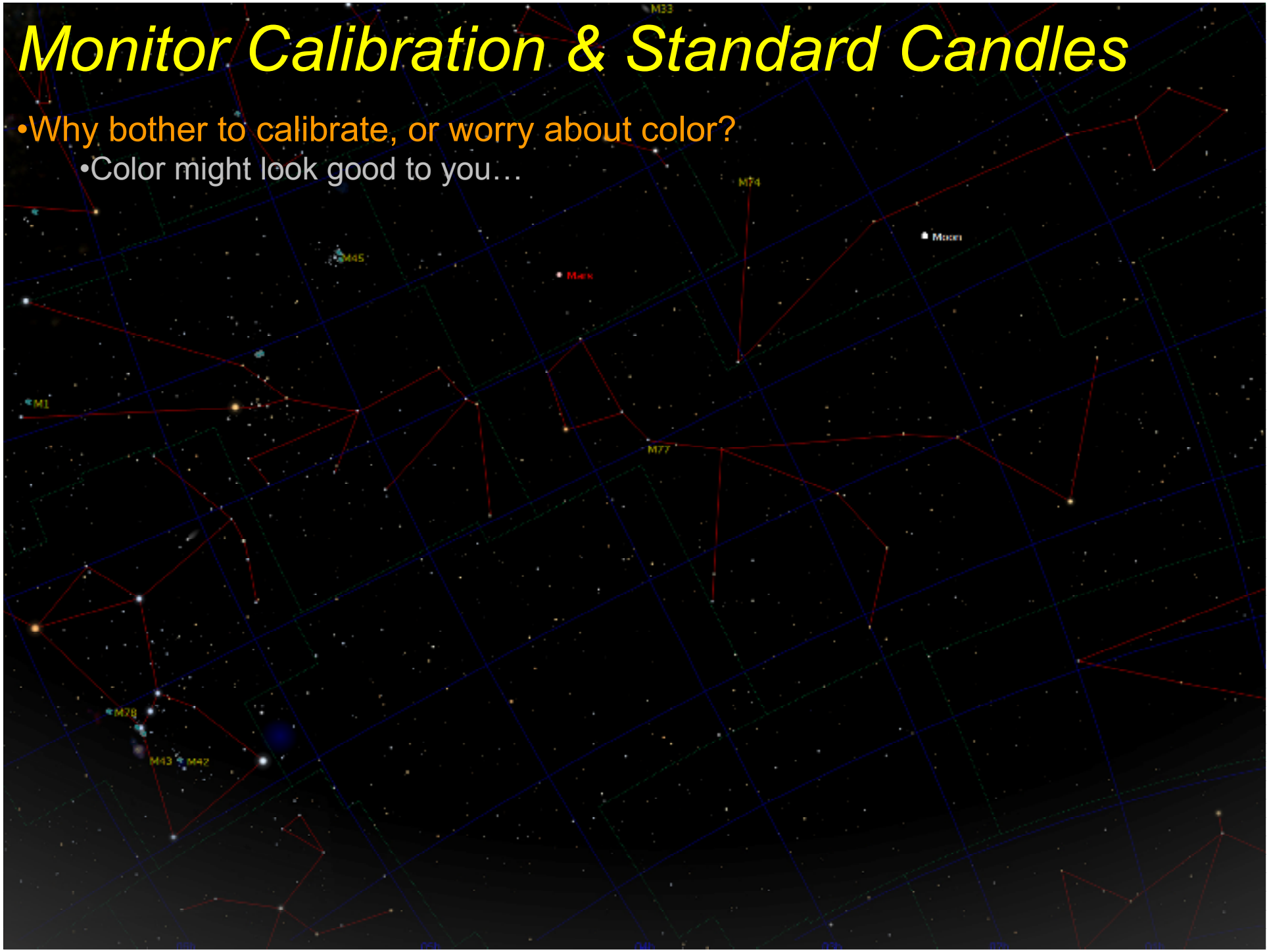
- Why bother to calibrate, or worry about color?
  - Color might look good to you…



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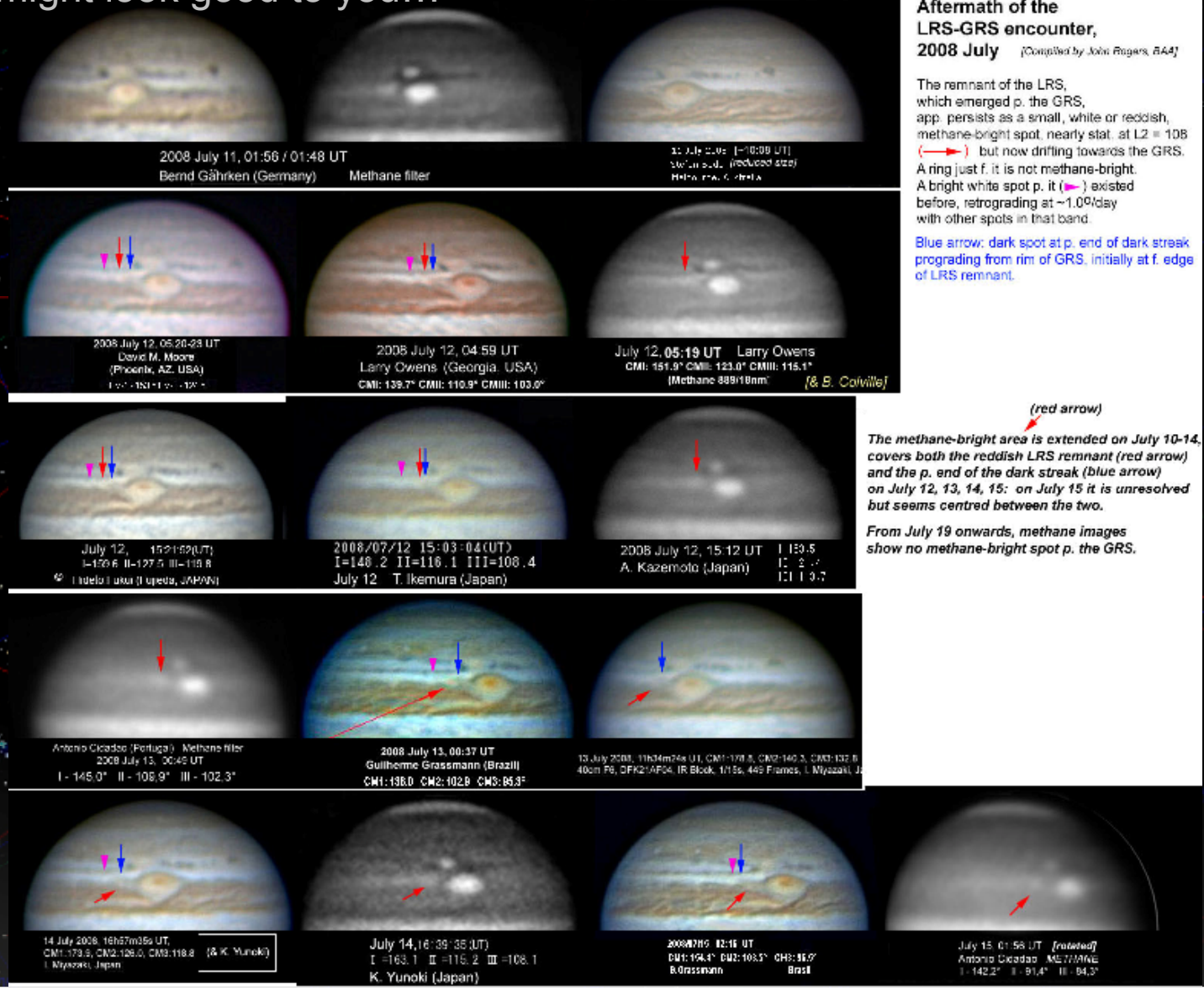

Aftermath of the LRS-GRS encounter, 2008 July *[Compiled by John Rogers, BAA]*

The remnant of the LRS, which emerged p. the GRS, app. persists as a small, white or reddish, methane-bright spot, nearly stat. at L2 = 108 (⟶) but now drifting towards the GRS. A ring just f. it is not methane-bright. A bright white spot p. it (►) existed before, retrograding at ~1.0°/day with other spots in that band.

Blue arrow: dark spot at p. end of dark streak prograding from rim of GRS, initially at f. edge of LRS remnant.

(red arrow)

The methane-bright area is extended on July 10-14, covers both the reddish LRS remnant (red arrow) and the p. end of the dark streak (blue arrow) on July 12, 13, 14, 15: on July 15 it is unresolved but seems centred between the two.

From July 19 onwards, methane images show no methane-bright spot p. the GRS.

Monitor Calibration & Standard Candles

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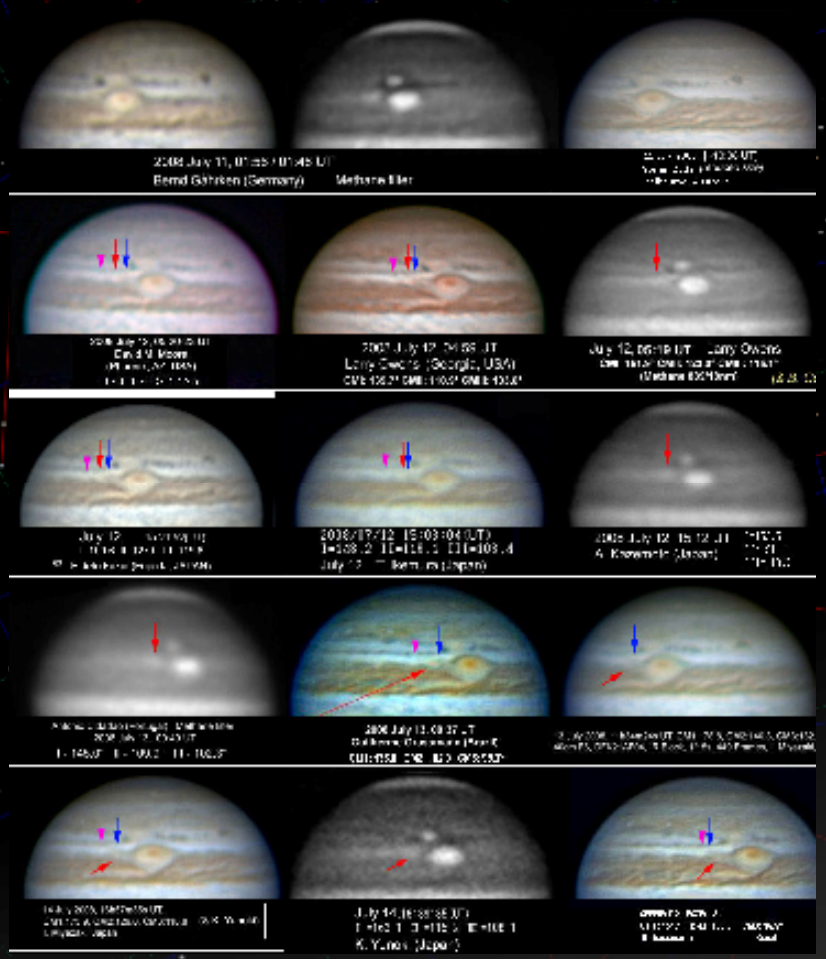
  - Color might look good to you…
    - Monitors can present color in dramatically different hues
    - Flat panels tend to exaggerate hues in shadows
    - Laptops
      - Some tend to desaturate color
      - Others can have a bias toward BLUE
    - CRT monitors provide the best tonal quality



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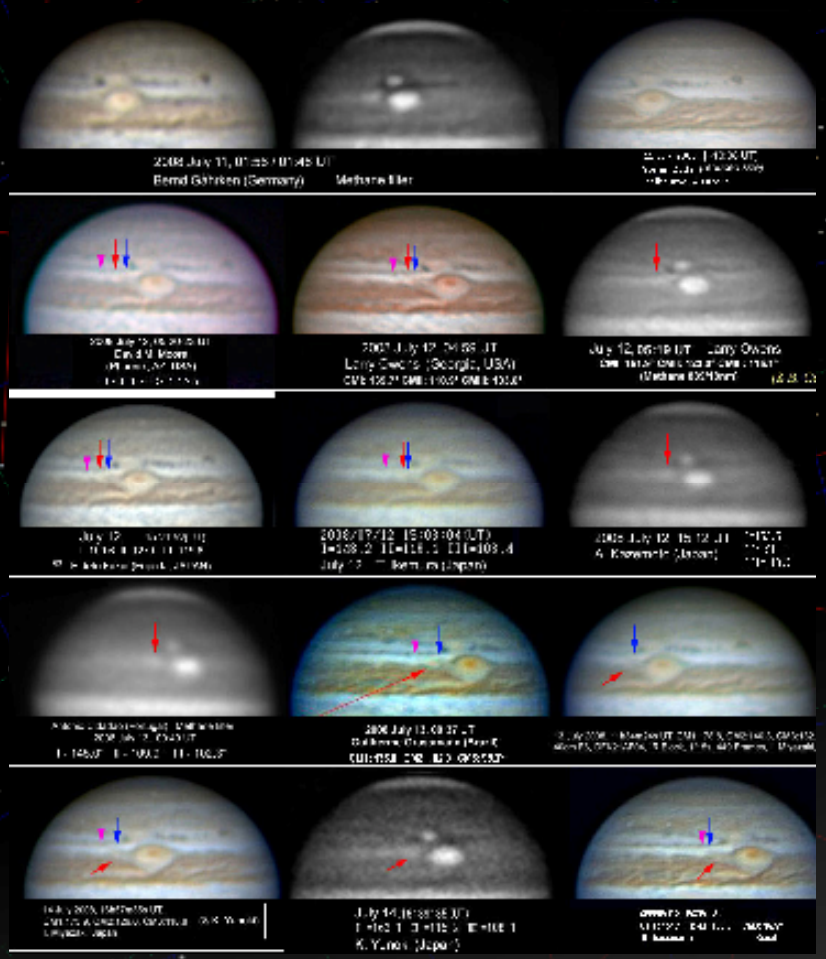

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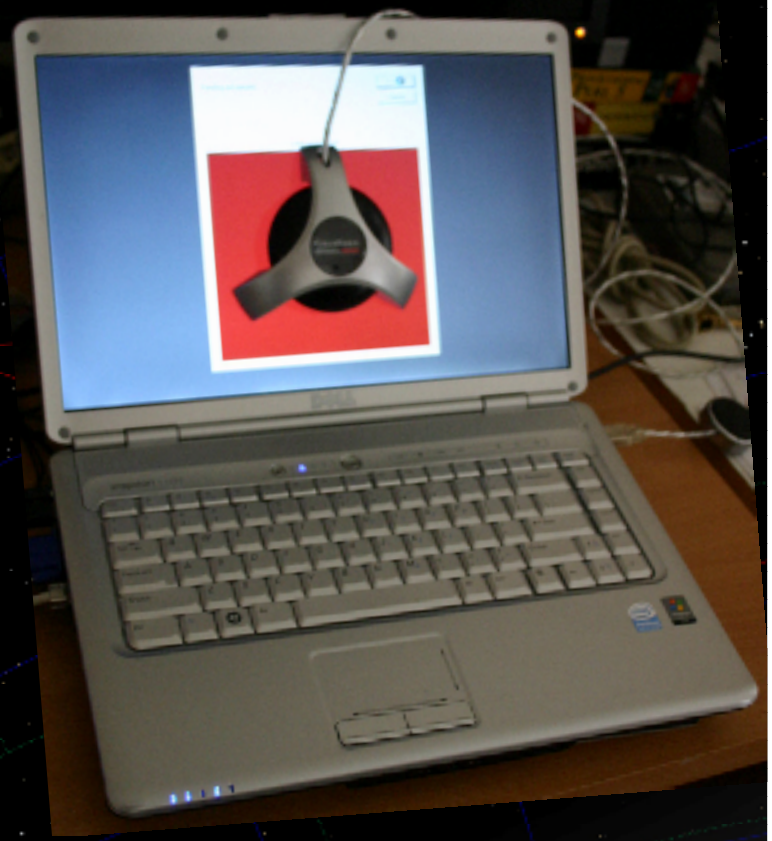
      - Spyder (may not work well on flat pannels)
      - Adobe Gamma
      - NOT the complete solution



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    - Process side by side with a "Standard Image"
      - Standard can be:
        - Any image generally accepted to be true color
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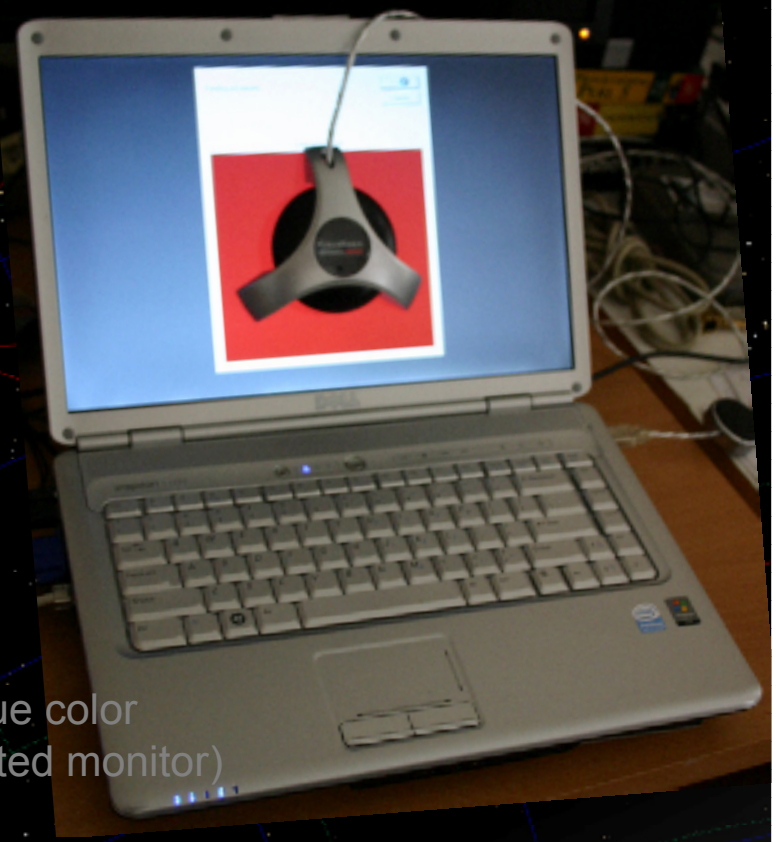

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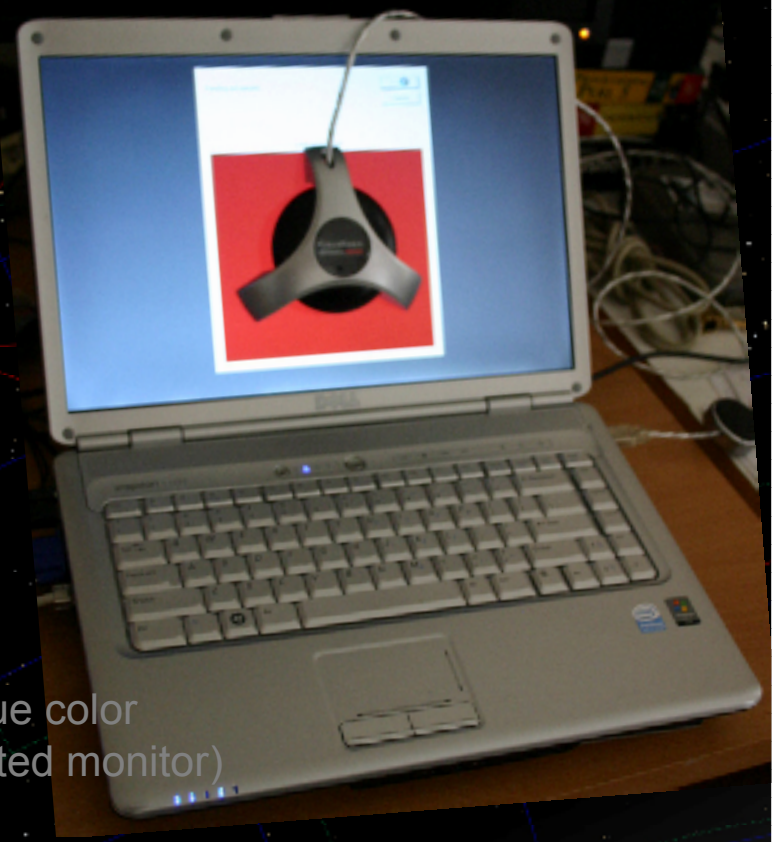

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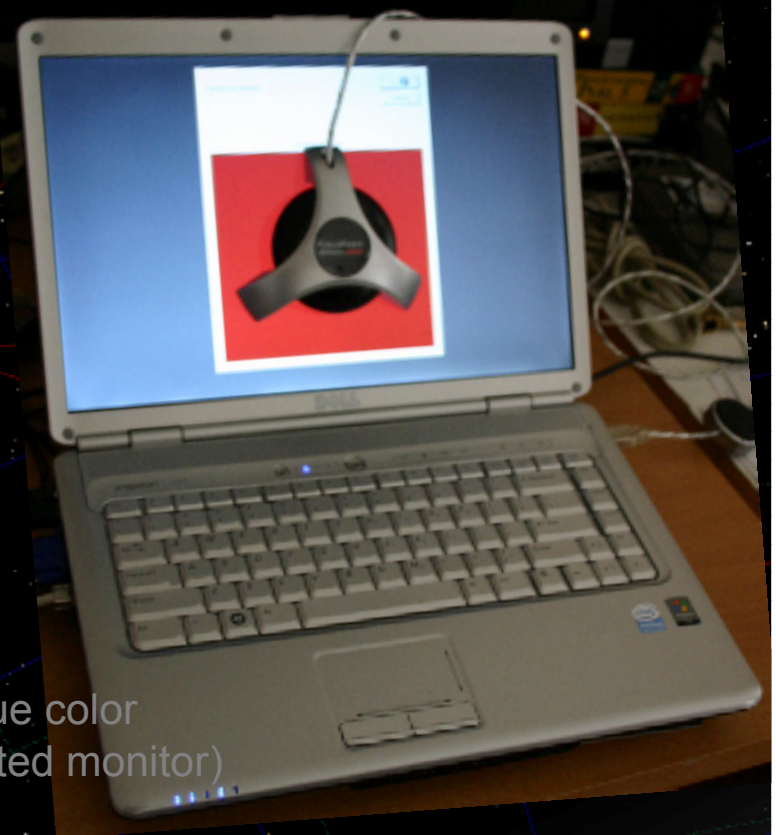
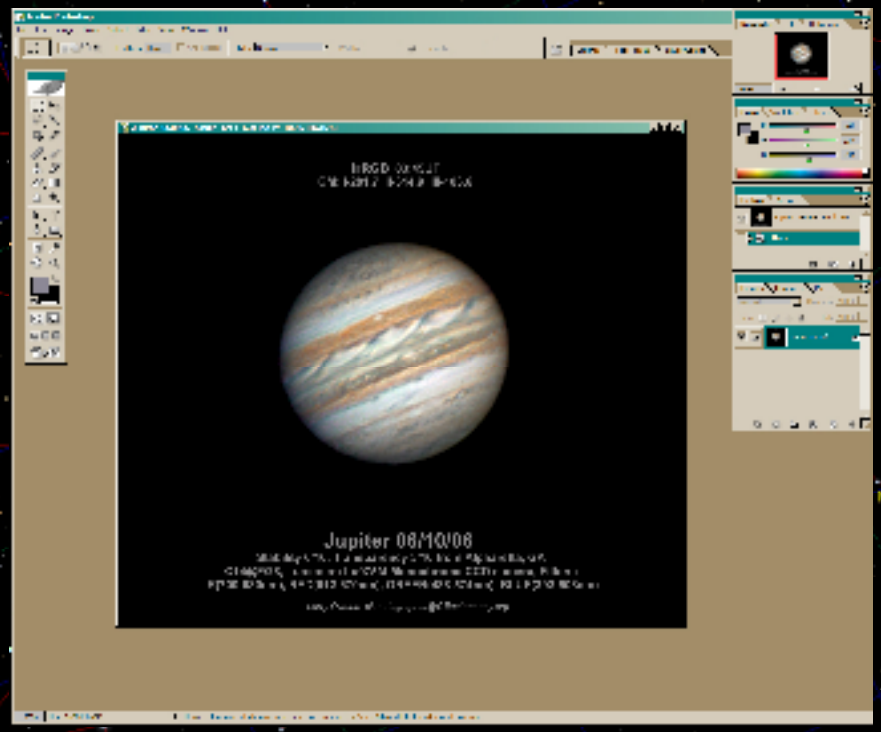
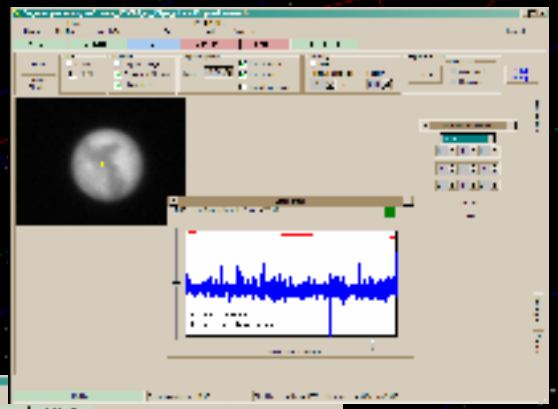
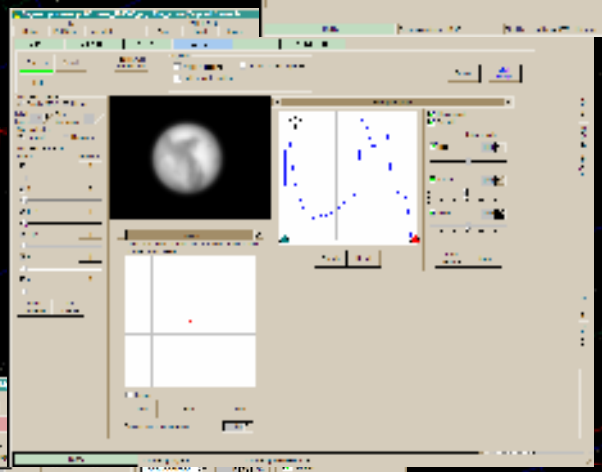
  - Why use a "Standard"
    - Human perception changes
      - With changes in ambient light – other factors
      - Loss of objectivity with long periods of processing
      - Process the image, do something else, look at it again later

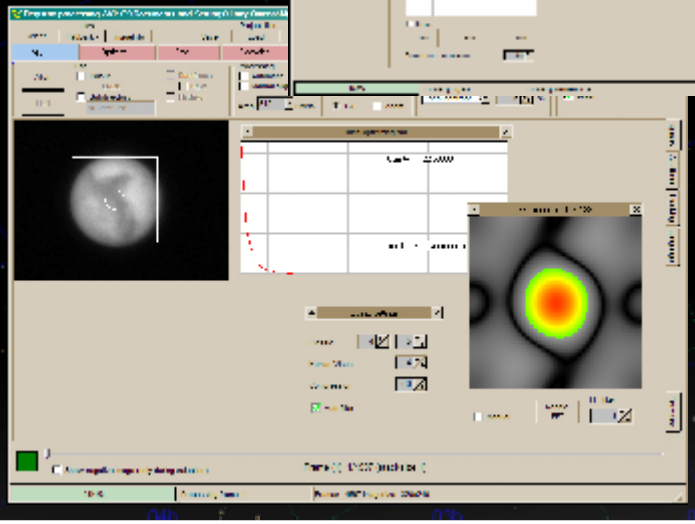


Standardized Processing Techniques



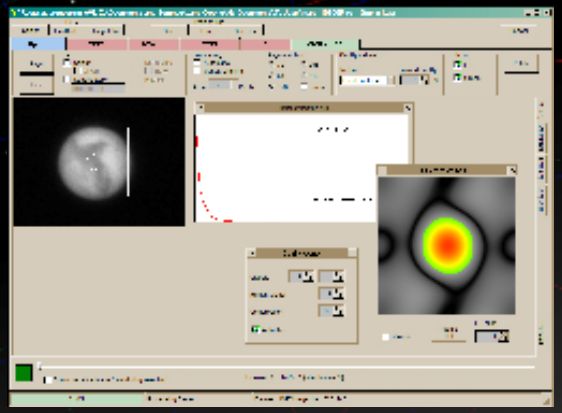






Standardized Processing Techniques

- What is meant by “standardized processing”
  - A method of processing that applies the same* enhancements to all images
    - *The same or nearly the same - doesn’t work in every situation
      - Images created from 500 frames can’t be processed the same as an image created from 1500 frames for example
  - Benefits:
    - Maintains relative contrast between filtered monochrome images
    - Maintains color correction by using a standard image
    - Saves time using “wavelet schemes” and “PhotoShop actions”



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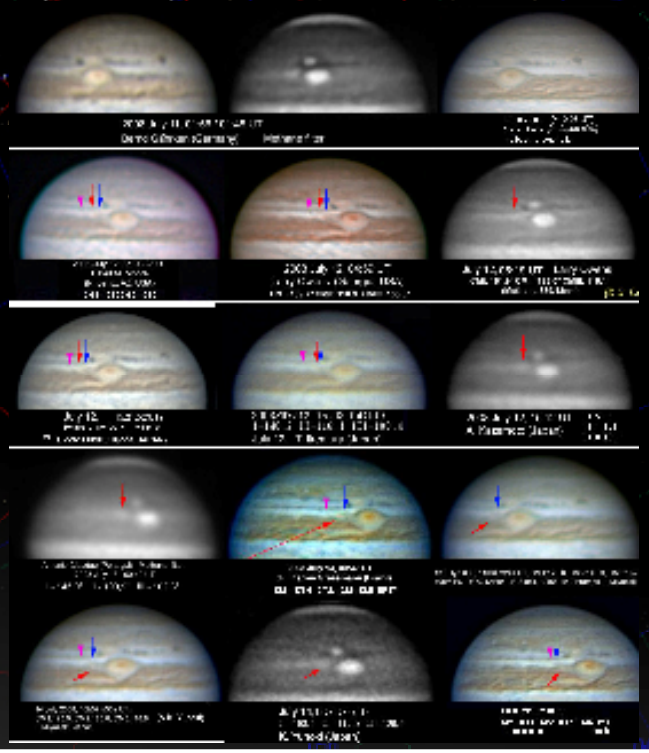

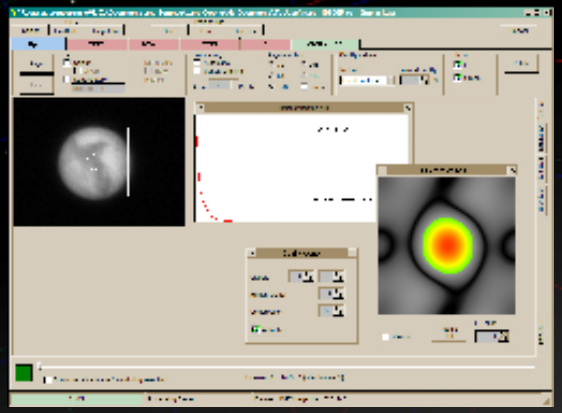

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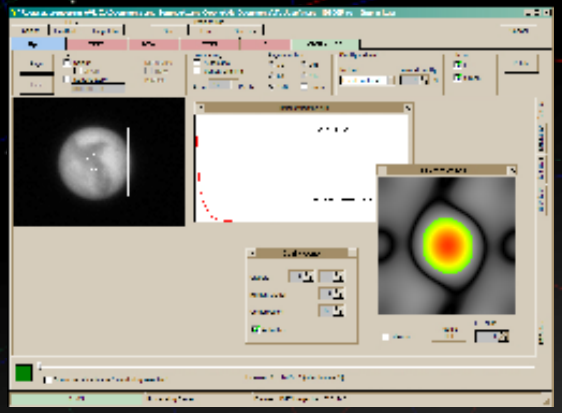
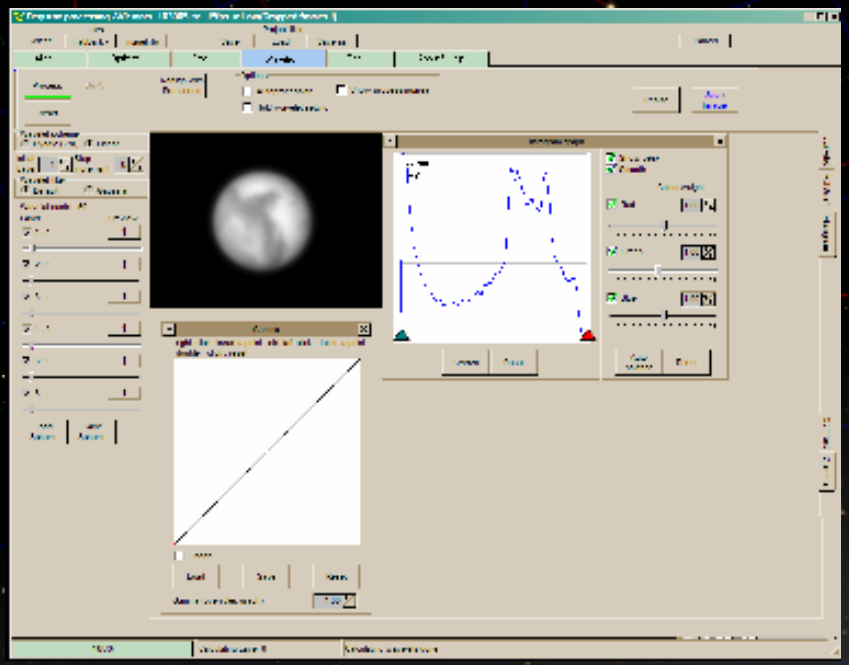
- The assembly line method
  - Processing all image sets for the session step by step
    - Align and stack all sets
    - Wavelet process all sets (with standard wavelet scheme for frame count)
    - Color combine all sets (with action set)
    - Color correct and enhance all sets (with action set)
  - Benefits:
    - Consistency
    - Time savings



Standardized Processing Techniques

- Creating "Wavelet Schemes"
  - Save a series of wavelet schemes for processing
    - Schemes will be different for images with different frame counts
      - Create several with anticipated numbers of frames
    - Create using some of your best RED filtered images
      - Process for a balance of detail vs. grain
      - Process modestly – more can be done in PhotoShop
      - Save the wavelet scheme
        - In the filename record frame count, contrast, or other settings
        - Example: wavelet_1500fr_90pct_contrast.rwv



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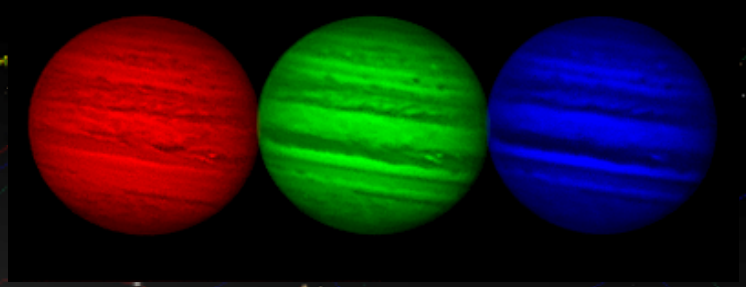
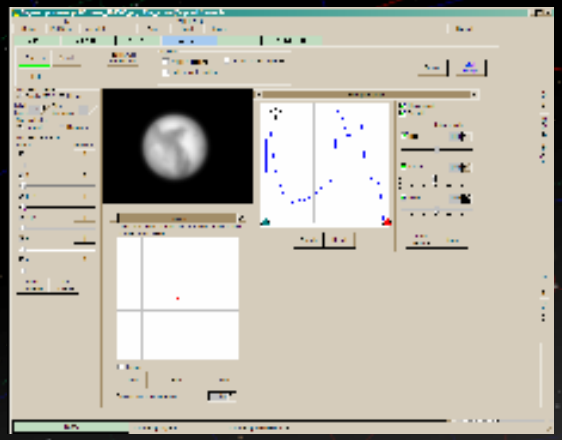
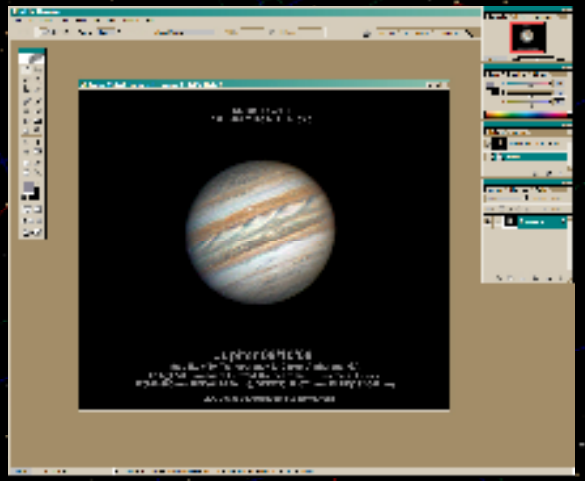
      - Save the wavelet scheme
        - In the filename record frame count, contrast, or other settings
        - Example: wavelet_1500fr_90pct_contrast.rwv
  - Use these schemes to process all filtered images (RED, GREEN, BLUE, IR)
    - Don't forget to also adjust contrast, etc (as specified in filename)
    - Use same settings for all filtered images
      - Important: This preserves the relative contrast between colors
    - Takes only seconds to process



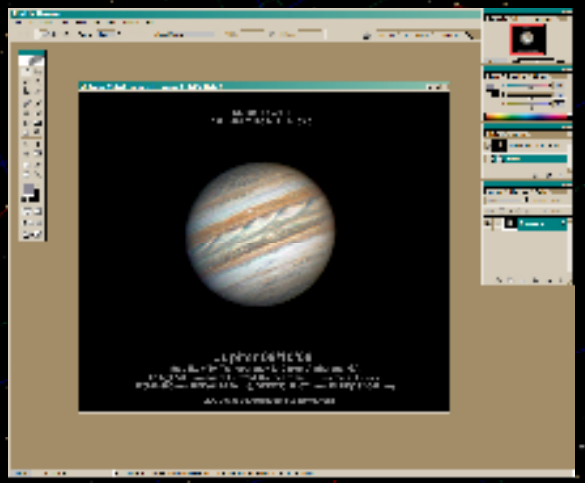


Standardized Processing Techniques



- Creating PhotoShop "Action Sets"
  - Sets
    - Groups of "actions"
  - Actions
    - Almost anything you can do manually
    - Playing, performs the same functions automatically
  - Creating action sets
    - Simple – process a color image, write down every detail of the steps taken
    - Create a "set" giving it a descriptive name
    - Process the image again, after pressing the "begin recording" button

Standardized Processing Techniques



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    - Almost anything you can do manually
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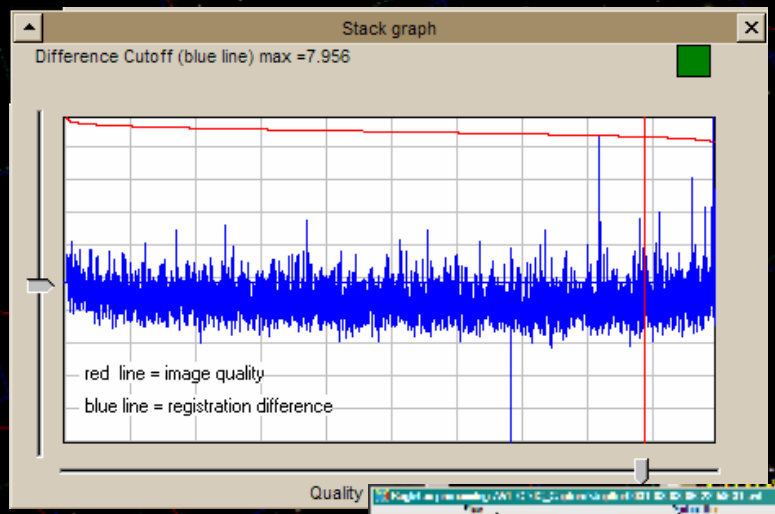
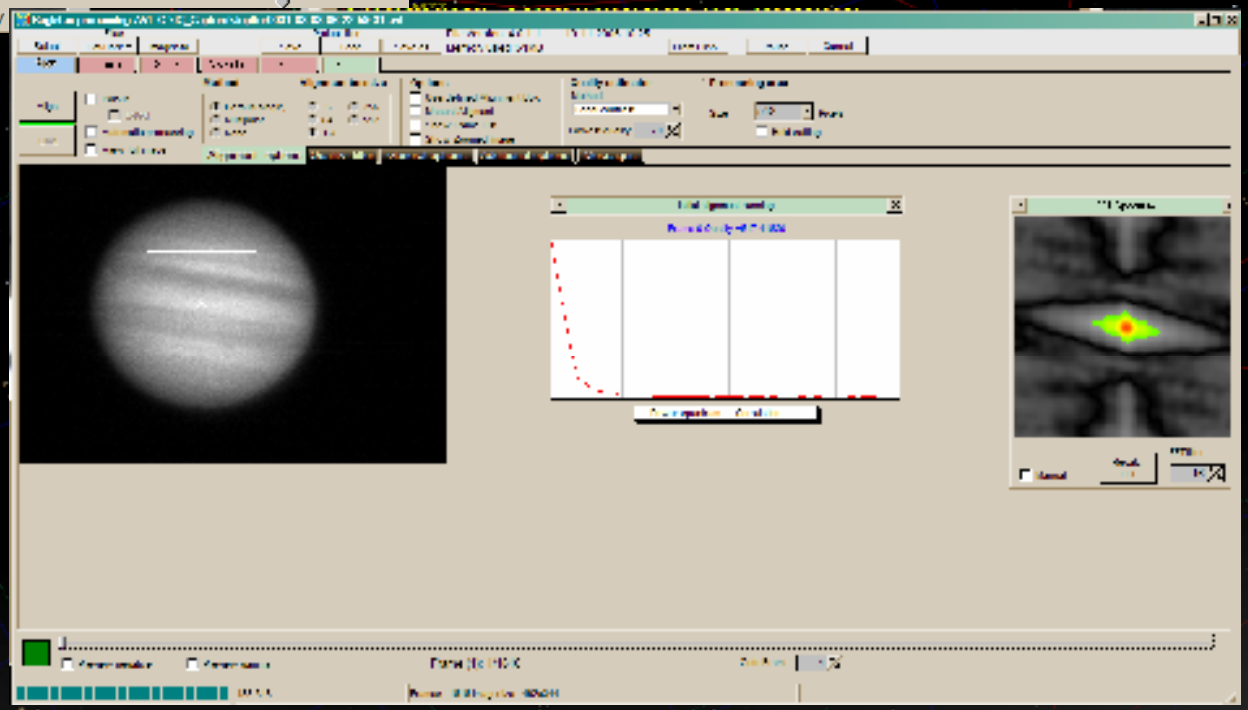
  - Creating action sets
    - Simple – process a color image, write down every detail of the steps taken
    - Create a "set" giving it a descriptive name
    - Process the image again, after pressing the "begin recording" button
  - Some issues and caveats
    - Some interactive tasks, may require a separate action
      - Creating a mask or selection area for example
  - Action sets for Jupiter
    - Each planet has unique processing needs
      - Action sets created with Jupiter images, should probably be used only with Jupiter

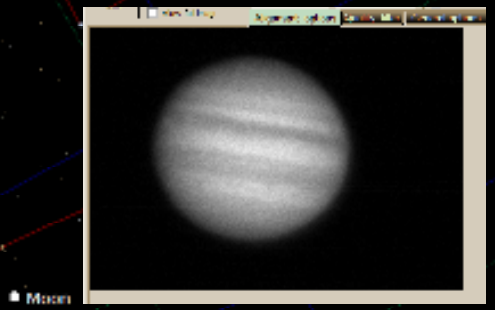
Registax Techniques for Jupiter

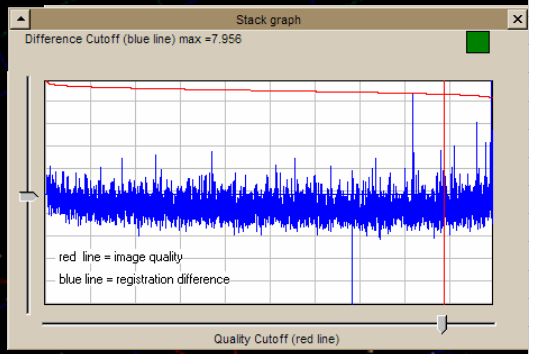


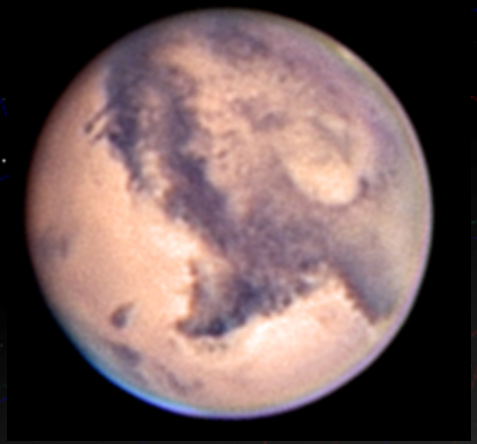


Registax Techniques for Jupiter

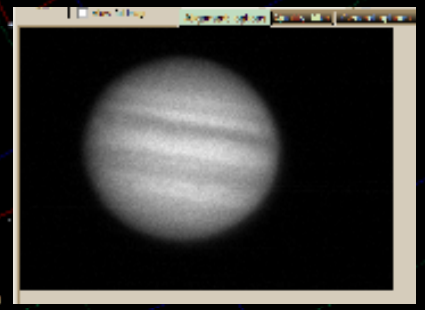
- Each Planet has Unique Processing Requirements
  - Jupiter
    - Has abundant atmospheric detail
    - Very fast rotation period so motion can be an issue
    - Currently low to the south (from northern hemisphere)

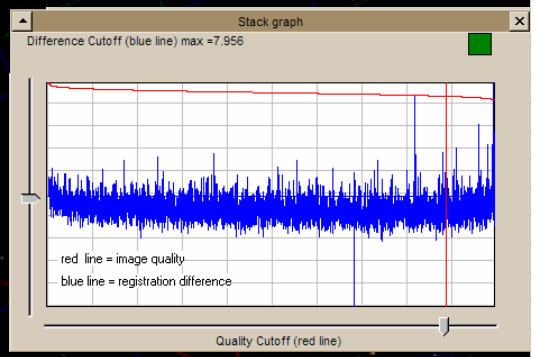






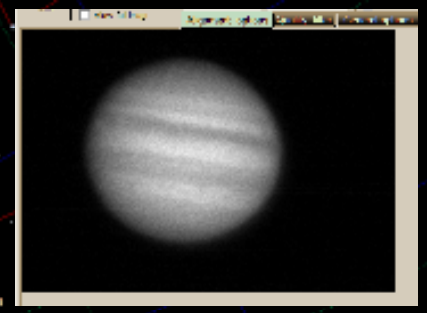
Registax Techniques for Jupiter

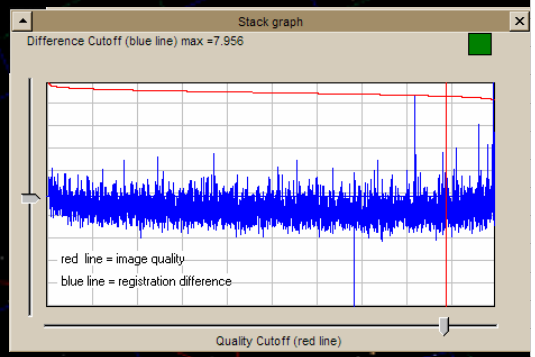




- Each Planet has Unique Processing Requirements
  - Jupiter
    - Has abundant atmospheric detail
    - Very fast rotation period so motion can be an issue
    - Currently low to the south (from northern hemisphere)
  - Techniques
    - Alignment
      - Use a small alignment box
        - Small enough to follow atmospheric features during alignment
        - Edges of box should be inside the planetary limb
      - Always optimize alignment
      - NEVER – “optimize and stack”

Registax Techniques for Jupiter





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      - Use a small alignment box
        - Small enough to follow atmospheric features during alignment
        - Edges of box should be inside the planetary limb
      - Always optimize alignment
      - NEVER – “optimize and stack”
    - Reference frame selection
      - Select one of the better frames – not necessarily the best
    - Selection of frames for stacking
      - Always open “stacking graph”
        - Select frames based on both alignment accuracy and quality

Processing Labs