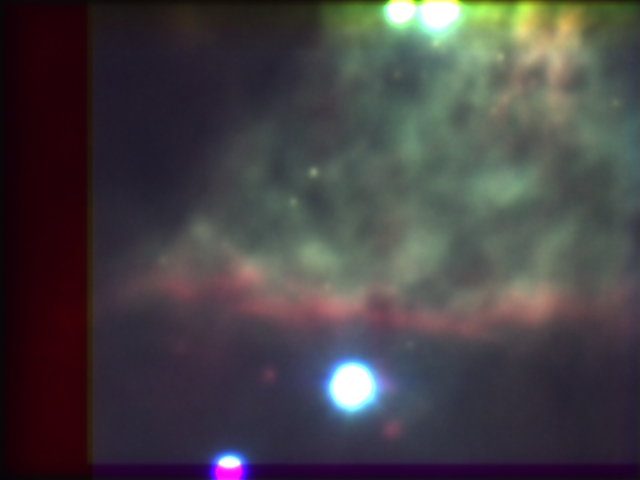
# 2019 Observing Notes

This is a “b” version of the document branched from a 2019-09-29 backup. The primary version was lost with the apparent loss of the Astrothumb3 128GB thumb drive on 2019-10-17. I believe that the only updates that had been made were to the 20190814UT Jupiter and Saturn observations section, with the Jovian Moons and Saturn work being completed. Also, the raw data from this observation day had been zipped and placed on the thumb drive. However, I believe they should exist on a backup of the laptop since they were resident on the laptop on 2019-09-29.



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## Year in Review

The past year I’ve focused on two main research activities

* Jupiter atmosphere analysis – Using the new C11 I did high resolution imaging. In addition, I did quantitative imaging at moderate resolution with the ST-2000XM. This allowed me to look at atmospheric absorption due to methane by comparing flux in the 940NIR (window) and the 889CH4 (absorption) filters.

## January

### Winter 2019 Planning

Last Updated 12/20/2017

* Observations – January 5th first visibility times; Dark around 6:00 pm
  + Imaging – wide field (135mm)
    - 8:30 pm –NGC1499 California Nebula (~~486HIB~~, 672SII, ~~658NII, 807NIR~~)
    - 10:00 pm – M42
    - 10:00 pm – Simeis 147
  + Video – 4500mm
    - 7:00 pm – Uranus – multiple broad (~~807NIR~~, 685NIR, 650RED, 550GRN, 450BLU)
    - 10:00 pm – M42 – ~~CRGB~~ covering the bar (2hrs total). Also, better focus. Key bands to add are 685NIR, 656HIA, 658NII, and 501OIII (2-4 hrs total)
* Analysis
  + M31 Multispectral Analysis *ala* M33, M81, M101 etc.
  + Solar Eclipse Movies, ratio analysis, etc.
  + Questions for OPT:
    - GoTo Mounts
    - Motorized Focuser
    - Custom Filters
  + Jupiter spectral reanalysis

### 2019-Jan-03 (Jan-04 UT): Mars and Uranus Video

Last Updated 1/7/2019

Very good seeing 4/5, but transparency degraded as clouds moved in during the 685NIR imaging of Uranus. I had not yet made deep exposures to detect moons, so establishing the orientation of Uranus unambiguously may be difficult.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-01-04-0154\_7-Mars\_650RED.avi | 0.05 | 50 | 50 | 1 | 320x240 |
| 2019-01-04-0157\_1-Mars\_685NIR.avi | 0.03 | 50 | 50 | 1 | 320x240 |
| 2019-01-04-0158\_6-Mars\_807NIR.avi | 0.03 | 50 | 50 | 2 | 320x240 |
| 2019-01-04-0201\_2-Mars\_450BLU.avi | 0.02 | 50 | 50 | 2 | 320x240 |
| 2019-01-04-0204\_0-Mars\_550GRN.avi | 0.05 | 50 | 50 | 1 | 320x240 |

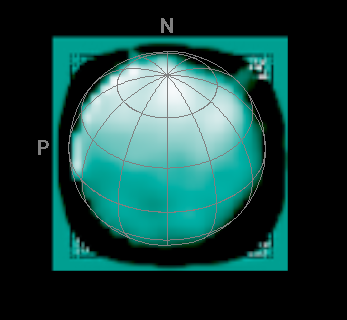
|  |  |  |
| --- | --- | --- |
|  |  |  |
| 2019-01-04-0158\_6-Mars\_807NIR.png | 2019-01-04-0157\_1-Mars\_685NIR.png | 2019-01-04-0154\_7-Mars\_650RED.png |
|  |  |  |
| 2019-01-04-0156\_8-Mars\_807NIR+685NIR+650RED.png | 2019-01-04-0204\_0-Mars\_550GRN.png | 2019-01-04-0201\_2-Mars\_450BLU.png |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 2019-01-04-0156\_8-Mars-807-685-650-RGB-ClrSmth-WhtBal-Sat150pct-Wavelets-L(R)RGB.png | 2019-01-04-0156\_8-Mars-807-685-650-RGB-ClrSmth-WhtBal-Sat150pct-Wavelets.png | 2019-01-04-0156\_8-Mars-807-685-650-RGB-ClrSmth-WhtBal-Sat150pct-Wavelets-L(B)RGB.png |
|  |  |  |
| 2019-01-04-0200\_0-Mars-RGB-ClrSmth-WhtBal-Wavelets-L(R)RGB.png | 2019-01-04-0200\_0-Mars-RGB-ClrSmth-WhtBal-Wavelets.png | 2019-01-04-0200\_0-Mars-RGB-ClrSmth-WhtBal-Wavelets-L(B)RGB.png |
|  |  |  |
| 2019-01-04-0200\_7-Mars-AllNIR+RED-G-B-RGB-ClrSmth-WhtBal-Wavelets-L(R)RGB.png | 2019-01-04-0200\_7-Mars-AllNIR+RED-G-B-RGB-ClrSmth-WhtBal-Wavelets.png | 2019-01-04-0200\_7-Mars-AllNIR+RED-G-B-RGB-ClrSmth-WhtBal-Wavelets-L(B)RGB.png |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-01-04-0235\_1-Uranus\_550GRN.avi | 0.999 | 100 | 50 | 2 | 1280x960 |
| Uranus-550GRN 2019-01-04T03\_01\_45Z | 2.0 | 100 | 50 | 2 | 1280x960 |
| Uranus-685NIR 2019-01-04T03\_10\_55Z | 2.0 | 100 | 50 | 2 | 1280x960 |
| 2019-01-04-0318\_0-Uranus\_550GRN.avi | 0.05 | 100 | 50 | 2 | 640x480 |
| 2019-01-04-0319\_3-Uranus\_450BLU.avi | 0.05 | 100 | 50 | 2 | 640x480 |
| 2019-01-04-0321\_2-Uranus\_650RED.avi | 0.1 | 100 | 50 | 2 | 640x480 |
| 2019-01-04-0327\_7-Uranus\_685NIR.avi | 0.3 | 100 | 50 | 2 | 640x480 |
| 2019-01-04-0332\_8-Uranus\_685NIR.avi | 0.3 | 100 | 50 | 2 | 640x480 |
| 2019-01-04-0337\_2-Uranus\_685NIR\_DARK.avi | 0.3 | 100 | 50 | 2 | 640x480 |
| 2019-01-04-0338\_2-Uranus\_650RED\_DARK.avi | 0.1 | 100 | 50 | 2 | 640x480 |
| 2019-01-04-0339\_0-Uranus\_550GRN\_DARK.avi | 0.05 | 100 | 50 | 2 | 640x480 |

TYC 0625-1184-1 is a nearby field start that appears in one of the early long-exposure sequences I took, before realizing it was not Uranus. In the images where both the star and planet appear, I can estimate an orientation and plate scale in order to navigate Uranus’s disk in WinJUPOS. I should add 2019-01-04-0311.0-Uranus-685NIR-Blur-2X.ims image with moon identifications.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 2019-01-04-0330\_3-Uranus\_685NIR.png | 2019-01-04-0321\_2-Uranus\_650RED.png | 2019-01-04-0318\_0-Uranus\_550GRN.png | 2019-01-04-0319\_3-Uranus\_450BLU.png |
|  |  |  |  |
| 2019-01-04-0322\_5-Uranus\_685NIR-RGB-Whtbal-L(R)RGB-Str-4X.png | 2019-01-04-0322\_5-Uranus\_685NIR-RGB-Whtbal-Str-4X.png | 2019-01-04-0322\_5-Uranus\_685NIR-RGB-Whtbal-L(B)RGB-Str-4x.png | 2019-01-04-0322\_5-Uranus\_NIRoverBLU.png |



Screen cap of grid over 2019-01-04-0322\_5-Uranus\_NIRoverBLU-PseudoColor.png to highlight the north polar brightness.

**Data Disposition:** Raw data is zipped on Astronomy Laptop and ready for archive on 2TB drive. Processed data is in appropriate project directories on the Astronomy thumb drive.

### 2019-Jan-08 (Jan-09 UT): NGC1499 California Nebula in 672SII

Last Updated 1/7/2019

Poor seeing 2/5, but very good transparency 4/5. Used a very old 501OIII flat field for calibration because I couldn’t get a good sky flat. I’d like to recalibrate when I get the chance with a good, recent 672SII flat.

|  |
| --- |
|  |
| NGC1499-SII-20190109UT-672SII-sum3h22m-Flattened-Log-HalfSize.jpg |

|  |  |
| --- | --- |
|  |  |
| NGC1499-SHO-WhtBal-HalfSize.jpg | NGC1499-SHO-NarrowBlend-WhtBal-HalfSize.jpg |

**Data Disposition:** Raw data is zipped on the 4TB drive. Processed data is in appropriate project directories on the Astronomy thumb drive.

### 2019-Jan-13 (Jan-14 UT): Mars, Moon and M42 Video (RGB)

Last Updated 1/7/2019

Very good seeing 4/5 and very good transparency 4/5. The C8 corrector plate started too frost up during the 450BLU videos of M42.

**MARS**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-01-14-0207\_8-Mars\_450BLU.avi | 0.03 | 50 | 50 | 2 | 640x480 |
| 2019-01-14-0210\_3-Mars\_550GRN.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-01-14-0212\_2-Mars\_650RED.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-01-14-0213\_8-Mars\_685NIR.avi | 0.03 | 50 | 50 | 1 | 640x480 |
| 2019-01-14-0214\_9-Mars\_685NIR.avi | 0.03 | 50 | 50 | 1 | 640x480 |
| 2019-01-14-0216\_4-Mars\_807NIR.avi | 0.03 | 50 | 50 | 2 | 640x480 |
| 2019-01-14-0218\_0-Mars\_807NIR.avi | 0.03 | 50 | 50 | 2 | 640x480 |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 2019-01-14-0217\_2-Mars\_807NIR.png | 2019-01-14-0214\_3-Mars\_685NIR.png | 2019-01-14-0212\_2-Mars\_650RED.png |
|  |  |  |
| 2019-01-14-0214\_6-Mars\_807+685+650-Wavelets.png | 2019-01-14-0210\_3-Mars\_550GRN.png | 2019-01-14-0207\_8-Mars\_450BLU.png |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 2019-01-14-0214\_6-Mars-807-685-650-RGB-ClrSmth-WhtBal-Wavelets-L(R)RGB.png | 2019-01-14-0214\_6-Mars-807-685-650-RGB-ClrSmth-WhtBal-Wavelets.png | 2019-01-14-0214\_6-Mars-807-685-650-RGB-ClrSmth-WhtBal-Wavelets-L(B)RGB.png |
|  |  |  |
| 2019-01-14-0210\_1-Mars-RGB-ClrSmth-WhtBal-Wavelets-L(R)RGB.png | 2019-01-14-0210\_1-Mars-RGB-ClrSmth-WhtBal-Wavelets.png | 2019-01-14-0210\_1-Mars-RGB-ClrSmth-WhtBal-Wavelets-L(B)RGB.png |
|  |  |  |
| 019-01-14-0210\_9-Mars-AllRed+NIR-GB-RGB-ClrSmth-WhtBal-Wavelets-L(R)RGB.png | 2019-01-14-0210\_9-Mars-AllRed+NIR-GB-RGB-ClrSmth-WhtBal-Wavelets.png | 2019-01-14-0210\_9-Mars-AllRed+NIR-GB-RGB-ClrSmth-WhtBal-Wavelets-L(B)RGB.png |

Note that for the first time this apparition, the south polar cap is undetectable.

**Data Disposition: *Mars*** raw data is zipped on Astronomy Laptop and ready for archive on 2TB drive. Processed data is in appropriate project directories on the Astronomy thumb drive.

**MOON**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | | | **Gain** | **Gamma** | | **Binning** | | **Capture Area** |
| 2019-01-14-0223\_3-Moon\_807NIR.avi | 0.07 | | | 50 | 50 | | 2 | | 640x480 |
| 2019-01-14-0224\_8-Moon\_685NIR.avi | 0.07 | | | 50 | 50 | | 1 | | 640x480 |
| 2019-01-14-0231\_0-Moon\_685NIR.avi | 0.015 | | | 50 | 50 | | 2 | | 640x480 |
| 2019-01-14-0232\_9-Moon\_685NIR.avi | 0.015 | | | 50 | 50 | | 2 | | 640x480 |
| 2019-01-14-0234\_3-Moon\_685NIR.avi | 0.01 | | | 50 | 50 | | 2 | | 640x480 |
| 2019-01-14-0238\_2-Moon\_685NIR.avi | 0.01 | | | 50 | 50 | | 2 | | 640x480 |
| 2019-01-14-0240\_6-Moon\_685NIR.avi | 0.02 | | | 50 | 50 | | 2 | | 640x480 |
| 2019-01-14-0242\_9-Moon\_685NIR.avi | 0.03 | | | 50 | 50 | | 2 | | 640x480 |
| 2019-01-14-0246\_0-Moon\_685NIR.avi | 0.03 | | | 50 | 50 | | 2 | | 640x480 |
| 2019-01-14-0247\_6-Moon\_685NIR.avi | 0.03 | | | 50 | 50 | | 2 | | 640x480 |
| 2019-01-14-0249\_4-Moon\_685NIR.avi | 0.03 | | | 50 | 50 | | 2 | | 640x480 |
| 2019-01-14-0251\_7-FLAT2X\_685NIR.avi | | 0.03 | 50 | | | 50 | | 2 | 640x480 |
| 2019-01-14-0252\_3-FLAT1X\_685NIR.avi | | 0.12 | 50 | | | 50 | | 1 | 640x480 |
| 2019-01-14-0256\_0-Moon\_685NIR.avi | | 0.03 | 50 | | | 50 | | 2 | 640x480 |

|  |  |
| --- | --- |
|  |  |
| RIMA HYGINUS  2019-01-14-0223\_3-Moon\_807NIR-Stack2102X-Wavelets1x20+2x10.png | RIMA HYGINUS  2019-01-14-0224\_8-Moon\_685NIR-Stack200-Wavelets1x10+2x5-Gam1.2.png |
|  |  |
| POSIDONIUS  2019-01-14-0231\_0-Moon\_685NIR-Stack8002X-Wavelets1x25+2x15.png | ENDYMION  2019-01-14-0234\_3-Moon\_685NIR-Stack8002X-Wavelets1x35+2x15.png |
|  |  |
| MARE HUMBOLDTIANUM  2019-01-14-0238\_2-Moon\_685NIR-Stack6752X-Wavelets1x30+2x15.png | ALPINE VALLEY  2019-01-14-0240\_6-Moon\_685NIR-Stack750-2X-Wavelets1x30+2x10.png |
|  |  |
| MONTES ALPES  2019-01-14-0246\_0-Moon\_685NIR-Stack5002X-Wavelets1x50-Gam.png | MONS PITON & PIAZZI SMYTH  2019-01-14-0247\_6-Moon\_685NIR-Stack5002X-Wavelets1x25+2x15-Gam.png |
|  |  |
| CRATER NAME?  2019-01-14-0249\_4-Moon\_685NIR-Stack400-2X-Wavelets1x30+2x10.png | ARZACHEL & DELAUNAY  2019-01-14-0256\_0-Moon\_685NIR-Stack250-2X-Wavelets1x20+2x5.png |

**Data Disposition: *Moon*** raw data is zipped on Astronomy Laptop and ready for archive on 2TB drive. Processed data is in appropriate project directories on the Astronomy thumb drive.

**M42 – Bright Bar**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Frame Directory** | **Temp (C)** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| M42-650RED 2019-01-14T04\_59\_05Z | -4.0 | 2.0 | 100 | 50 | 2 | 1280x960 |
| M42-550GRN 2019-01-14T05\_21\_06Z | -3.2 | 2.0 | 100 | 50 | 2 | 1280x960 |
| M42-450BLU 2019-01-14T05\_33\_05Z | -3.2 | 2.0 | 100 | 50 | 2 | 1280x960 |
| Dark-2s 2019-01-14T05\_45\_21Z | -4.0 | 2.0 | 100 | 50 | 2 | 1280x960 |

|  |  |
| --- | --- |
|  |  |
| M42-650RED-Stack254-sum08m28s.jpg | M42-550GRN-Stack253-sum08m26s.jpg |
|  |  |
| M42-650BLU-Stack272-sum09m04s.jpg | M42-20190114UT-RGB-Blur-ClrSmth-WhtBal.jpg |

**Data Disposition: *M42*** raw data is zipped on Astronomy Laptop and ready for archive on 2TB drive. Processed data is in appropriate project directories on the Astronomy thumb drive.

### 2019-Jan-14 (Jan-15 UT): M42 Video (656HIA, 658NII, 672NII, 685NIR, 501OII)

Last Updated 1/7/2019

Moderate seeing 3/5, but very good transparency 4/5. I used my frost protection tube extension on the C8. It was rather windy also.

When I was taking videos at the red end (656HIA, 685NIR, 658NII, and 672SII) I was using my phone to control the laptop. I apparently didn’t hit “enter” when changing the names on the videos for each filter. I have three videos named “658NII”. I believe they are in fact, in chronological order: 685NII, 672SII?, and 685NIR.

Need to talk about synthesizing darks of the right temperature.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Frame Directory** | **Temp (C)** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| M42-685NIR 2019-01-15T04\_56\_22Z | -4.7 | 2.0 | 100 | 50 | 2 | 1280x960 |
| M42-656HIA 2019-01-15T05\_07\_15Z | -5.5 | 2.0 | 100 | 50 | 2 | 1280x960 |
| M42-658NII 2019-01-15T05\_18\_12Z | -4.7 | 2.0 | 100 | 50 | 2 | 1280x960 |
| M42-672SII 2019-01-15T05\_29\_19Z | -5.5 | 2.0 | 100 | 50 | 2 | 1280x960 |
| M42-685NIR 2019-01-15T05\_40\_00Z | -6.2 | 2.0 | 100 | 50 | 2 | 1280x960 |
| M42-501OIII 2019-01-15T05\_53\_55Z | -5.5 | 2.0 | 100 | 50 | 2 | 1280x960 |
| Dark-2s 2019-01-15T06\_06\_18Z | -6.2 | 2.0 | 100 | 50 | 2 | 1280x960 |

|  |  |
| --- | --- |
|  |  |
| M42-20190115UT-685NIR-sum08m42s.jpg | M42-20190115UT-672SII-sum05m18s.jpg |
|  |  |
| M42-20190115UT-658NII-sum06m50s.jpg | M42-20190115UT-656HIA-sum06m16s.jpg |
|  |  |
| M42-20190115UT-501OIII-sum05m30s.jpg | M42-20190115UT-XXX-RGB-NHO-WhtBal-Blur-Wavelets.png |
|  |  |
| M42-20190115UT-XXX-RGB-685-656-501-WhtBal-Blur-Wavelets.png |  |

**Data Disposition:** Raw data is zipped on the 4TB drive. Processed data is in appropriate project directories on the Astronomy thumb drive.

## April

### Spring 2019 Planning

Last Updated 4/4/2019

* Observations – Twilight around 8:50pm on April 23
  + Double Stars Video – 4500mm
    - 12 Lyn – 8:30
    - Castor & YY Gem – 8:30 - triple
    - 38 Gem – 8:00 – why do I not have an orbit for this in the Python code?
    - Eta Gem – 8:00
    - Del Gem – 8:00
    - Sirius – 8:00
    - Zet Can – 8:30 - triple
    - **Eps Hyd – 9:00 – triple**
    - Gam Leo – 9:00
    - Iot Leo – 10:30
    - Xi Uma – 10:30
    - Porrima – 11:00
    - Xi Boo – 1:00am
    - **44 Boo – 1:00am**
  + Morning Planets – 4500mm
    - Jupiter
    - Venus
  + Galaxies – 1260mm
    - M65 – 9:00 – Leo
    - M66 – 9:00 –Leo
    - NGC3628 – 9:00 –Leo
    - M81 – 9:00 – UMa – Need narrow band (486HIB, **501OIII (+2hrs)**, 658NII (maybe), **672SII**) for compositional gradient analysis. Also, still need several NIR channels (742NIR, 807NIR, 889NIR)
    - M82 – 9:00 – UMa – Multiband?
    - M51 – 10:00 – Uma – 656HIA and maybe 501OIII
    - M101 – 10:30 – UMa – 656HIA and maybe 501OIII
* Analysis
  + Jupiter spectroscopy and atmospheric vertical modeling – need to wrap up analysis at a clearly documented stopping point.
  + Double star analysis updates and update Multiple Star Astrometry report
  + Should figure out what to do with individual star analyses, e.g., Vega, Castor
  + Galaxy composition gradient analysis
    - M31 Multispectral Analysis *ala* M33, M81, M101 etc.
    - Update M81 analysis with new narrowband data
  + Solar Eclipse Movies, ratio analysis, etc.
  + Questions for OPT
    - GoTo Mounts
    - Motorized Focuser
    - Custom Filters

## May

### 2019-May-12 (May 13 UT) Double Star and Moon Videos

Last Updated 5/13/2019

Had very steady seeing (4/5), but transparency was mediocre (3/5) with high and spotty/thin clouds.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-05-13-0303\_0-Castor\_685NIR.avi | 0.01 | 50 | 50 | 2 | 320x240 |
| 2019-05-13-0305\_6-Castor\_685NIR.avi | 0.03 | 50 | 50 | 1 | 320x240 |
| 2019-05-13-0308\_2-Castor\_685NIR.avi | 0.2 | 50 | 81 | 1 | 1280x960 |
| 2019-05-13-0310\_9-Castor\_685NIR\_Drift.avi | 0.2 | 50 | 50 | 1 | 1280x960 |
| 2019-05-13-0327\_2-ZetCnc\_685NIR.avi | 0.1 | 80 | 50 | 1 | 640x480 |
| 2019-05-13-0339\_5-GamLeo\_685NIR.avi | 0.02 | 50 | 50 | 1 | 320x240 |
| 2019-05-13-0341\_4-GamLeo\_685NIR\_Drift.avi | 0.1 | 50 | 50 | 1 | 1280x960 |
| 2019-05-13-0351\_2-IotLeo\_685NIR.avi (NOT) | 0.1 | 80 | 50 | 1 | 320x240 |
| 2019-05-13-0358\_0-IotLeo\_685NIR.avi | 0.05 | 80 | 50 | 1 | 320x240 |
| 2019-05-13-0407\_9-XiUMa\_685NIR.avi | 0.1 | 50 | 50 | 1 | 320x240 |
| 2019-05-13-0412\_2-Moon\_685NIR.avi | 0.0504 | 50 | 50 | 1 | 1280x960 |
| 2019-05-13-0419\_7-Plato\_685NIR.avi | 0.1 | 50 | 50 | 1 | 1280x960 |
| 2019-05-13-0427\_9-Porrima\_685NIR.avi | 0.1 | 50 | 50 | 1 | 320x240 |
| 2019-05-13-0429\_5-Porrima\_685NIR\_Drift.avi | 0.1 | 100 | 50 | 1 | 1280x960 |

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| **Castor** | | **Castor** | |
|  | 2019-05-13-0303\_0-Castor\_685NIR-Stack300-2X-Wavelets2x5-RotCrop.jpg |  | 2019-05-13-0305\_6-Castor\_685NIR-Stack200-Wavelets1x10-RotCrop.jpg |
| **YY Gem** | | **Zet Cnc** | |
| G:\Astronomy\2014\08\11b\Aligned\Rotated+Cropped\LamOph 8_11_2014 10_57_38 PM Stack300 -Wavelets1x6+2x3.jpg | LamOph 8\_11\_2014 10\_57\_38 PM Stack300 -Wavelets1x6+2x3.jpg |  | 2019-05-13-0327\_2-ZetCnc\_685NIR-Stack120-Wavelets1x10-RotCrop.jpg |
| **Gam Leo** | | **BU 648** | |
|  | 2019-05-13-0339\_5-GamLeo\_685NIR-Stack300-Wavelets1x10-RotCrop.jpg |  | 2019-05-13-0358\_0-IotLeo\_685NIR-Stack120-Wavelets1x10-Gam150pct-RotCrop.jpg |
| **Xi UMa** | | **Porrima** | |
| G:\Astronomy\2014\08\11b\Aligned\Rotated+Cropped\EPSLYR-B 8_11_2014 11_42_31 PM Stack300 - Wavelets1x6+2x3.jpg | 2019-05-13-0407\_9-XiUMa\_685NIR-Stack120-Wavelets1x10-RotCrop.jpg |  | 2019-05-13-0427\_9-Porrima\_685NIR-Stack60-Wavelets1x10-RotCrop.jpg |

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| 2019-05-13-0412\_2-Moon\_685NIR-Stack80-Wavelets1x5+2x10-Gam150pct.png | 2019-05-13-0419\_7-Plato\_685NIR-Stack80-Wavelets1x30-Gam150pct.png |

**Data Disposition:** Raw data is zipped on the 4TB drive. Processed data is in appropriate project directories on the Astronomy thumb drive.

### Summer 2019 Planning

Last Updated 4/4/2019

* Observations – Astro twilight begins around 9:10pm on Aug 8
  + Double Stars Video – 4500mm
    - Xi Boo – 8:30pm
    - 44 Boo – 8:30pm
  + Galaxies – 1260mm
    - M51 – 9:30 – UMa – 656HIA and maybe 501OIII
    - M101 – 10:00 – UMa – 656HIA and maybe 501OIII
  + Planetary Nebulae
    - M57
      * Lucky imaging (non-linear) – 467HeII, 486HIB, 658NII (more 672SII?)
      * **Linear imaging – Start with missing narrow blue bands:** 467HeII, 486HIB, 501OIII, **656HIA, 658NII,** 672SII
    - NGC 6543
      * Lucky imaging (non-linear) – 550CLR, 450BLU, 550GRN, 650RED
      * **Linear imaging – Start with missing narrow blue bands: 467HeII, 486HIB**, 501OIII, 656HIA, 658NII, 672SII
  + Planets – 4500mm
    - Jupiter – 12:00am (still rising) – very low apparition
      * Full longitudinal coverage for atmospheric state
      * Multiple coverage of longitudes for circulation
      * **Experiment with filters, absorption, and color slopes (ASI120MM and *maybe* ST2000XM) [*Mendikoa et al.*, 2017; *Ordonez-Etxeberria et al.*, 2016]**
        + **Do 467HeII and 486HIB in the blue and 889CH4 and 940NIR in the NIR. Can do a synthetic GRN from 467 & 940 for a simulated (extended) RGB. Would do CH4 investigation with 889 & 940. Use 685NIR for acquisition and context imaging.**
      * **Moon imaging**
        + High resolution of Galilean moons if a steady night
        + **Photometry of Galilean moons – same bands as Jupiter filter imaging – provides some relative reflectance info and also orbital phase variations using 685NIR filter.**
        + **Distant moons using either 550CLR or 685NIR filter**
      * Possible spectra Jupiter reference and higher SNR on moons
    - Saturn
      * Spectra – need deep enough exposures with 135mm lens
        + **100 lpm with 135mm lens: 550CLR and 685NIR – this is pretty essential to creating a two component spectral model for Saturn and its rings. I’m not sure how to mount the ST2000XM without the C8 now, however!**
        + 200 lpm: 550CLR and 685NIR
      * Imaging
        + High resolution – try to get Encke gap, storms, and hexagon
        + **Experiment with filters, absorption, and color slopes (ASI120MM and *maybe* ST2000XM). Mainly try to get deeper 889CH4 images than I’ve gotten previously.**
        + Seeliger effect on rings (and Titan?)
      * Titan
        + **100 lpm spectra at 1760mm: 550CLR and 685NIR**
        + 200 lpm spectra at 1760mm: 550CLR and 685NIR
        + **Titan photometry, including 940NIR window, to look for variations due to surface features [*Bouchez*, 2004]. Also, use same filter set as Jupiter for context and reference (467HeII, 486HIB, 685NIR, 889CH4, 940NIR). Would be good to see a detection in the 889CH4 band, which I don’t think I’ve done before.**
* Analysis
  + General code cleanup and consolidation
    - Astrophysical target data codes
    - Observational metadata codes
    - Observational data codes
    - Plot setup codes
    - Start deleting organic spectroscopic and EW codes
  + Photometry updates
    - **Numeric output**
    - Catalog data input
    - Response and transformation to standard filters
    - Variable stars and time series plots
    - Blackbody fit and Wein’s law temperature
  + Spectroscopy updates
    - Make codes, including Vega, more generic
    - **Blackbody fit and Wein’s law temperature (new code)**
    - Spline fit for normalization (create class or generic routine)
    - Integration into EW Utils
    - **Line-based temperatures (H I and Na II)**
    - Consolidate EW plotting codes, e.g., EW vs line strength or N vs line strength (Jupiter and Vega…)
    - Balmer thermometer?
  + Jupiter spectroscopy and atmospheric vertical modeling – need to wrap up analysis at a clearly documented stopping point.
  + Should figure out what to do with individual star analyses, e.g., Vega, Castor
  + Galaxy composition gradient analysis
    - M31 Multispectral Analysis *ala* M33, M81, M101 etc.
    - Update M81 analysis with new narrowband data
  + Solar Eclipse Movies, ratio analysis, etc.
  + Questions for OPT
    - GoTo Mounts
    - Motorized Focuser

## July

### 2019-July-10 (July 11 UT) Jupiter and Moon Video; Celestron 11 Setup and Testing

Last Updated 7/23/2019

**CHECKLIST**

Here’s a checklist for my initial setup and checkout of the C11.

* Add 21 lb. counterweight and test balance. I needed the 21lb weight plus the 7lb weight to adequately counterbalance the telescope.
* Roll out the telescope. See how the heavier weight affects the difficulty of moving and maneuvering the telescope. See if it’s less stable vertically with the higher weight (the CM should be the same.) Align to north. The telescope is so tall that it needs to be rotated to clear the door of the shed. If balanced well, the telescope is easily pointed. However, the GM8 is a bit light for the C11 payload. It flexes significantly when moved and takes a few moments to damp. I suspect that during light to medium wind, it would be quite unstable. It’s hard to tell if the higher weight makes the tripod-telescope combination less stable while rolling. I aligned the telescope on a new “pad” made of three pavers close to the shed. I accidentally got very good polar alignment and marked the spots on the pads.
* Investigate how to use the finder. Is there an eyepiece needed? Where is it? Do I use one of mine? The finder requires a crosshair eyepiece. I used my 12mm Plossel reticle eyepiece (no longer has a functioning illuminator). It’s unclear what the focal length of the objective is, so I’m unsure of the magnification. The eyepiece is adjusted with three thumbscrews, which is how it is aligned. I purchased a 9mm Plossel illuminated reticle eyepiece as a potential replacement for the 12mm. The 50mm aperture provided good illumination and should be much better than the 6x30 finder on the C8 in the bright skies of Denver.
* Investigate the Telrad. Does it have batteries? How to use it – brightness, alignment? It takes two AA batteries. A brightness control is on the right. And, it’s aligned using three screws on the back.
* Insert eyepieces into C11 and co-align finder with scope. Do a rough test on collimation by looking at test targets (Jupiter, Moon, star(s)). I co-aligned the guider and scope by imaging the Moon and using the reticle marks on the 12mm Plossel eyepiece. The eyepiece can be adjusted by the three set screws holding it in, or by the set screws for the finder itself. It took a few iterations to get everything lined up.
* Hook up ST2000XM (on electronics box) to provide guiding control. Done. Might be nice to have something to hold it solidly rather than just sitting on the electronics box.
* Insert ASI120MM and begin imaging tests at 2800mm (~0.27 arcsec-pix-1 plate scale). Done. Very nice results. Also did some 2x2 binned imaging. WinJUPOS showed the plate scale to match expectations quite well at 0.28 arcsec-pix-1.

Seeing was good, 3.5/5. Probably rated above 4 if only looking at the NAM 300mb map. Transparency varied with patchy clouds. During clear intervals, it was probably 3.5/5.

I think the collimation was pretty good, but there’s room for improvement. I should do a good star collimation.

**Next steps:**

* **Configure filter wheel for standard broadband planetary imaging (380,450,550,650,685,807,889)**
* **Image with 2x barlow**
* **Check/adjust collimation**

**FIRST LIGHT**

**MOON**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| Straight Wall (Rupes Recta)  2019-07-11-0244\_3-Moon\_650RED.avi | 0.002 | 50 | 50 | 2 | 1280x960 |
| Straight Wall (Rupes Recta)  2019-07-11-0245\_8-Moon\_650RED.avi | 0.002 | 50 | 50 | 2 | 640x480 |
| Rima Hyginus  2019-07-11-0247\_6-Moon\_650RED.avi | 0.002 | 50 | 50 | 2 | 1280x960 |
| Rima Hyginus  2019-07-11-0248\_8-Moon\_650RED.avi | 0.002 | 50 | 50 | 2 | 640x480 |
| Rima Hyginus  2019-07-11-0250\_6-Moon\_685NIR.avi | 0.001 | 50 | 50 | 2 | 640x480 |
| Rima Hyginus  2019-07-11-0251\_5-Moon\_685NIR.avi | 0.005 | 50 | 50 | 1 | 640x480 |
| Plato  2019-07-11-0255\_4-Moon\_685NIR.avi | 0.005 | 50 | 50 | 1 | 640x480 |
| Plato  2019-07-11-0256\_3-Moon\_685NIR.avi | 0.005 | 50 | 50 | 1 | 320x240 |
| Plato  2019-07-11-0256\_8-Moon\_685NIR.avi | 0.005 | 50 | 50 | 1 | 320x240 |
| Plato  2019-07-11-0259\_0-Moon\_685NIR.avi | 0.0015 | 50 | 50 | 2 | 320x240 |
| Plato  2019-07-11-0259\_4-Moon\_685NIR.avi | 0.0015 | 50 | 50 | 2 | 320x240 |
| Posidonius  2019-07-11-0301\_4-Moon\_685NIR.avi | 0.003 | 50 | 50 | 1 | 640x480 |
| Posidonius  2019-07-11-0302\_2-Moon\_685NIR.avi | 0.003 | 50 | 50 | 1 | 320x240 |
| Posidonius  2019-07-11-0302\_8-Moon\_685NIR.avi | 0.003 | 50 | 50 | 1 | 320x240 |

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| 2019-07-11-0244\_3-Moon\_650RED-Stack200-Wavelets1x20-Gam150pct.png | 2019-07-11-0245\_8-Moon\_650RED-Stack400-Wavelets1x20-Gam150pct.png |
|  |  |
| 2019-07-11-0247\_6-Moon\_650RED-Stack200-Wavelets1x20-Gam120pct.png | 2019-07-11-0248\_8-Moon\_650RED-Stack400-Wavelets1x20-Gam120pct.png |
|  |  |
| 2019-07-11-0250\_6-Moon\_685NIR-Stack400-Wavelets1x20-Gam140pct.png | 2019-07-11-0251\_5-Moon\_685NIR-Stack400-Wavelets1x20+2x10-Gam120pct.png |
|  |  |
| 2019-07-11-0255\_4-Moon\_685NIR-Stack400-Wavelets1x20+2x10-Gam150pct.png | 2019-07-11-0256\_5-Moon\_685NIR-Stack2000-Wavelets1x30+2x20-Gam150pct-Wavelets.png |
|  |  |
| 2019-07-11-0259\_2-Moon\_685NIR-Stack1600-Wavelets1x20-2X-Wavelets.png | 2019-07-11-0301\_4-Moon\_685NIR-Stack400-Wavelets1x20+2x15.png |
|  |  |
| 2019-07-11-0302\_6-Moon\_685NIR-Stack1600-Wavelets1x30+2x10-Wavelets.png |  |

**JUPITER**

0.2801 arcsec-pix-1, rotation =350.74 deg – from alignment of Jupiter with moons (2019-07-11-0352\_0-Jupiter\_685NIR.avi) in WinJUPOS.

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| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-07-11-0316\_5-Jupiter\_685NIR.avi | 0.015 | 50 | 50 | 1 | 320x240 |
| ~~2019-07-11-0317\_1-Jupiter\_685NIR.avi~~ | 0.015 | 50 | 50 | 1 | 320x240 |
| 2019-07-11-0337\_9-Jupiter\_450BLU.avi | 0.02 | 50 | 50 | 1 | 320x240 |
| 2019-07-11-0339\_3-Jupiter\_450BLU.avi | 0.02 | 50 | 50 | 1 | 320x240 |
| 2019-07-11-0341\_0-Jupiter\_501OIII.avi | 0.1 | 50 | 50 | 1 | 320x240 |
| 2019-07-11-0344\_7-Jupiter\_656HIA.avi | 0.1 | 50 | 50 | 1 | 320x240 |
| 2019-07-11-0346\_0-Jupiter\_672SII.avi | 0.1 | 50 | 50 | 1 | 320x240 |
| 2019-07-11-0347\_6-Jupiter\_658NII.avi | 0.15 | 50 | 50 | 1 | 320x240 |
| 2019-07-11-0349\_7-Jupiter\_650RED.avi | 0.015 | 50 | 50 | 1 | 320x240 |
| 2019-07-11-0350\_7-Jupiter\_685NIR.avi | 0.01 | 50 | 50 | 1 | 320x240 |
| 2019-07-11-0352\_0-Jupiter\_685NIR.avi  (Jupiter, Io, & Ganymede) | 0.01 | 50 | 50 | 1 | 640x480 |

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| 2019-07-11-0343\_3-Hill-Jupiter-RED-OIII-BLU-RGB-WhtBal-Wavelets.png | 2019-07-11-0343\_7-Hill-Jupiter-685-OIII-BLU-RGB-WhtBal-Wavelets.png |

Here are some thoughts on different filter ratios:

* 656HIA/658NII/672SII/<656HIA+658NII+672SII> may show evidence of:
  + Raman scattering from Hα emission. But it would only be evident if it was spatially variable due to cloud height or aerosol differences
  + Weak CH4 absorption at 668 nm in the 672SII filter. While the contrast would be low, it would appear as enhanced brightness over higher clouds (EB?) or higher aerosol areas (poles).

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| 2019-07-11-0346\_1-Hill-Jupiter-SII-NII-HIA for ratio-RGB-ManColAlign-R.png | 2019-07-11-0346\_1-Hill-Jupiter-SII-NII-HIA for ratio-RGB-ManColAlign-B.png | 2019-07-11-0346\_1-Hill-Jupiter-SIIoverHIA-ManColAlign.jpg |
|  |  |  |
| 2019-07-11-0346\_1-Hill-Jupiter-SII-NII-HIA for ratio-RGB-ManColAlign-R.png | 2019-07-11-0346\_1-Hill-Jupiter-SII-NII-HIA for ratio-RGB-ManColAlign-G.png | 2019-07-11-0346\_1-Hill-Jupiter-SIIoverNII-ManColAlign.jpg |
|  |  |  |
| 2019-07-11-0346\_1-Hill-Jupiter-SII-NII-HIA for ratio-RGB-ManColAlign-G.png | 2019-07-11-0346\_1-Hill-Jupiter-SII-NII-HIA for ratio-RGB-ManColAlign-B.png | 2019-07-11-0346\_1-Hill-Jupiter-NIIoverHIA-ManColAlign.jpg |

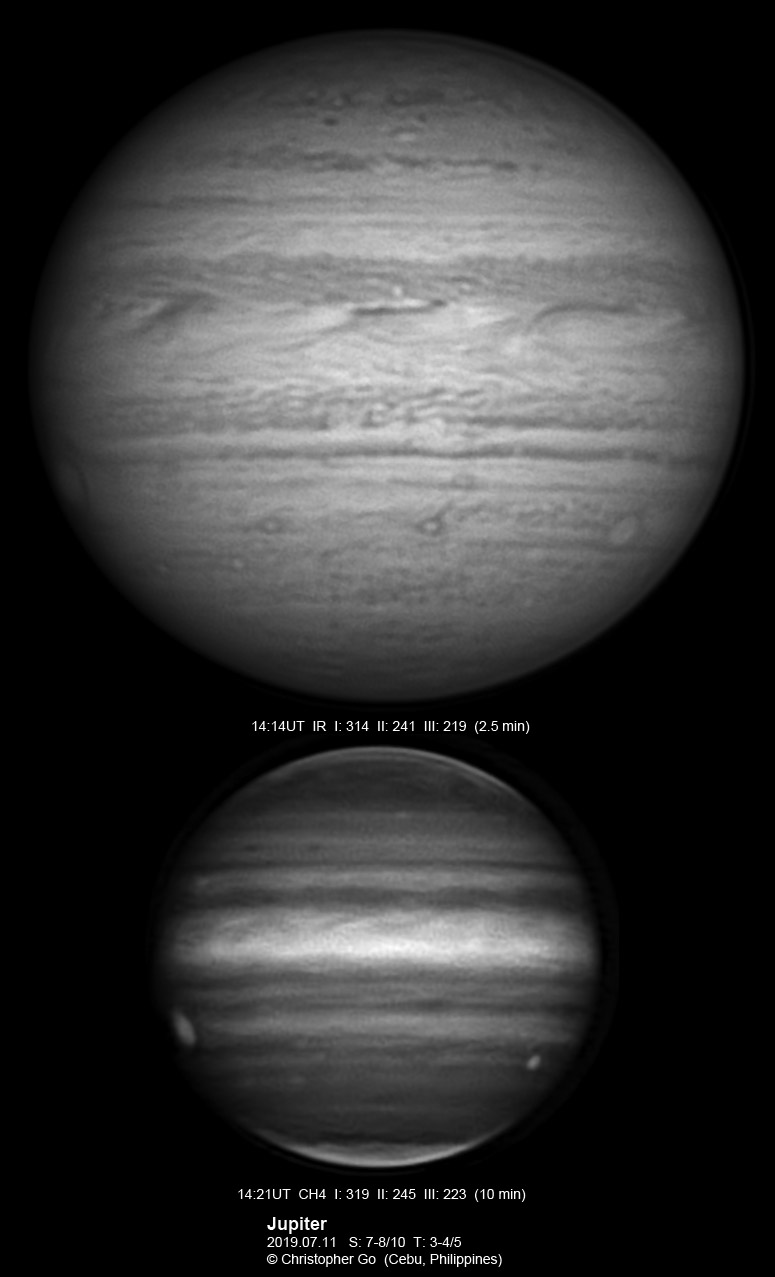
* red narrowband/650RED
  + The 650RED band will pick up a portion of the CH4 619 nm band and a portion of the weak 668 nm band. It will fully include the weak NH3 645 nm band. It is possible that this ratio will show differential absorption due to methane and or ammonia.

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| 2019-07-11-0346\_1-Jupiter\_SII+NII+HIA-Wavelets.png | 2019-07-11-0349\_7-Jupiter\_650RED.png | 2019-07-11-0347\_3-Hill-Jupiter-REDNB\_over\_RED-Smth-Str.jpg |

* 685NIR/650RED or 685NIR/red narrowband
  + Because there’s greater methane absorption in the 685NIR band than in either the 650RED or red narrowband regions, this ratio should show some differential methane absorption.

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| 2019-07-11-0339\_7-Jupiter\_685NIR-Wavelets.png | 2019-07-11-0349\_7-Jupiter\_650RED.png | 2019-07-11-0346\_4-Hill-Jupiter-NIRoverRED-Str-Smth.jpg |
|  |  |  |
| 2019-07-11-0339\_7-Jupiter\_685NIR-Wavelets.png | 2019-07-11-0346\_1-Jupiter\_SII+NII+HIA-Wavelets.png | 2019-07-11-0346\_4-Hill-Jupiter-NIRoverNarrowBandRED-Str-Smooth.jpg |

Scaling on ratios is 0.7 to 1.3. While some details are accentuated when dividing the 685NIR image by either the 650RED or red narrow band sum, they are not totally consistent with each other. Also, the images do not show the primary expected features of methane absorption such as a very bright equatorial band. Even though the variations are about ±30 percent, I think most of these variations may be due to differences in contrast and image sharpness.



j190711b2-CH4Ref.jpg

* 501OIII/450BLU
  + Both filters sample pure continuum, but with different effective wavelengths. If differences exist, they will be due to the “V”-B color slope due to broadband chromophore and aerosol effects.

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| 2019-07-11-0338\_6-Jupiter\_450BLU.png | 2019-07-11-0341\_0-Jupiter\_501OIII-Cont90.png | 2019-07-11-0340\_2-Hill-Jupiter-501OIIICont90\_over\_450BLU-Smth-Str.jpg |

OIII over BLU (both at 90% contrast) scaling is 1.3-1.7. Since the 450BLU image had to be contrast reduced to 90% after wavelet sharpening, the 501OIII was also reduced to 90% contrast. The ratio clearly shows features that appear physical in nature, including the brighter equatorial band (“green” over “blue”), positive slope with increasing wavelength. Whereas the NEB is darker, showing a negative slope.

* 501OIII/red narrowband
  + If one or more of the red narrow band channels can be shown to be a true continuum signal, the ratio would show the R-B color slope due to broadband chromophore and aerosol effects.

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| 2019-07-11-0341\_0-Jupiter\_501OIII.png | 2019-07-11-0346\_1-Jupiter\_SII+NII+HIA-Wavelets.png | 2019-07-11-0342\_7-Hill-Jupiter-REDnarrowband\_over\_501OIII-Smth-Str.jpg |

Rednarrowband over 501OIII (100% contrast) scaling is 1.5-3.0.

**JOVIAN MOONS**

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| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-07-11-0352\_0-Jupiter\_685NIR.avi  Jupiter, Io, & Ganymede | 0.01 | 50 | 50 | 1 | 640x480 |
| 2019-07-11-0352\_9-Jupiter\_685NIR.avi  Io, Ganymede, & Europa | 0.01 | 50 | 50 | 1 | 640x480 |
| 2019-07-11-0353\_8-Jupiter\_685NIR.avi  Io, Ganymede, & Europa | 0.02 | 50 | 50 | 1 | 640x480 |
| 2019-07-11-0359\_3-Callisto\_685NIR.avi  Callisto | 0.05 | 50 | 50 | 1 | 320x240) |

Note that applying too strong 1-pixel wavelets sharpening on Ganymede (and Callisto) can create an artifact that looks like a real albedo feature. At this plate scale, it would be best to use 2-pixel wavelets. If the 1-pixel transform is used, it should be used lightly and with caution.

|  |  |  |  |
| --- | --- | --- | --- |
| **IO**  **CM=329** | **EUROPA**  **CM=305** | **GANYMEDE**  **CM=203** | **CALLISTO**  **CM=278** |
| 2019-07-11-0352\_9-Io\_685NIR-MultiStack1200-Wavelets1x30-2X-Cropped.png | 2019-07-11-0353\_4-Europa\_685NIR-MultiStack800-Wavelets1x30-2X-Cropped.png | 2019-07-11-0352\_9-Ganymede\_685NIR-MultiStack1200-Wavelets1x30-2X-Cropped.png | 2019-07-11-0359\_3-Callisto\_685NIR-Stack300-Wavelets1x30-Str0to128-2X-Cropped.png |
|  |  |  |  |
|  |  |  |  |
| 2019-07-11-0352\_9-Io-WinJUPOSCapture-Mono-Smth.jpg | 2019-07-11-0353\_4-Europa-WinJUPOSCapture-Mono-Smth.jpg | 2019-07-11-0352\_9-Ganymede-WinJUPOSCapture-Mono-Smth.jpg | 2019-07-11-0359\_3-Callisto-WinJUPOSCapture-Mono-Smth.jpg |

**Data Disposition:** Raw data is zipped on the 4TB drive. Processed data is in appropriate project directories on the Astronomy thumb drive.

### 2019-July-23 (July 23 UT) Jupiter, Saturn, and Moons Videos

Last Updated 7/25/2019

The evening started out cloudy with thick cirrus, but later cleared. Transparency was 4/5 and seeing was also very good at 4/5. While it was still partly cloudy, I worked on some follow up tasks checking out the C11:

* I configure filter wheel for standard broadband planetary imaging (380,450,550,650,685,807,889). Also, I loaded the ST2000XM CFW8 with the new 467HeII filter along with the 486HIB, 501OIII, 742NIR, and 550OPN filters
* Imaging was conducted with 2x barlow lens, resulting in a finer plate scale than the prime focus imaging performed on 2019-07-11UT.
* I adjusted the collimation using Ganymede and Io as out-of-focus targets. Significant improvement was made, and the collimation is now quite good. However, there is probably still room for improvement and additional star testing should be conducted.

With the improved collimation and the very good seeing, the imaging results of Jupiter were quite impressive. They were as good or a bit better than my best imaging with the C8. Of course, the value of this C11 will only be proven over time under a variety of seeing conditions.

One clear highlight is that albedo detail is seen unambiguously on Ganymede.

**JUPITER**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-07-24-0415\_2-Jupiter\_685NIR.avi | 0.05 | 50 | 50 | 1 | 1280x960 |
| 2019-07-24-0416\_8-Jupiter\_685NIR.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-07-24-0418\_3-Jupiter\_650RED.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-07-24-0420\_1-Jupiter\_550GRN.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-07-24-0425\_2-Jupiter\_450BLU.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-07-24-0431\_3-Jupiter\_380NUV.avi | 0.5 | 80 | 50 | 2 | 640x480 |
| 2019-07-24-0435\_4-Jupiter\_889CH4.avi | 0.999 | 80 | 50 | 2 | 640x480 |
| 2019-07-24-0440\_3-Jupiter\_807NIR.avi | 0.2 | 50 | 50 | 1 | 640x480 |
| 2019-07-24-0444\_2-Dark\_380NUV.avi | 0.5 | 80 | 50 | 2 | 640x480 |
| 2019-07-24-0445\_0-Dark\_889CH4.avi | 0.999 | 80 | 50 | 2 | 640x480 |

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| 2019-07-24-0421\_2-Hill-Jupiter-RGB-WhtBal-ClrSmth-Smth-Wavelets4x25.png | 2019-07-24-0424\_9-Hill-Jupiter\_R(807)G(685)B(650)-RGB-WhtBal-ClrSmth-Smth-Sat200pct-Wavelets.png |
|  |  |
| 2019-07-24-0430\_6-Hill-Jupiter\_R(807)G(550)B(380)-RGB-WhtBal-ClrSmth-Smth-Wavelets.png | 2019-07-24-0428\_9-Hill-Jupiter\_R(889)G(550)B(380)-RGB-WhtBal-ClrSmth-Smth-Wavelets.png |

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| 2019-07-24-0435\_4-Jupiter\_889CH4.png | 2019-07-24-0440\_3-Jupiter\_807NIR.png | 2019-07-24-0416\_0-Jupiter\_685NIR-Combined-Wavelets.png |
|  |  |  |
| 2019-07-24-0418\_3-Jupiter\_650RED.png | 2019-07-24-0420\_1-Jupiter\_550GRN.png | 2019-07-24-0425\_2-Jupiter\_450BLU.png |
|  |  |  |
| 2019-07-24-0431\_3-Jupiter\_380NUV.png |  |  |

**JUPITER MOONS**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-07-24-0411\_9-Ganymede+Io\_685NIR.avi | 0.1 | 50 | 50 | 1 | 1280x960 |
| 2019-07-24-0413\_1-Ganymede+Io\_685NIR.avi | 0.1 | 50 | 50 | 1 | 1280x960 |

|  |  |  |  |
| --- | --- | --- | --- |
| **IO**  **CM=99** | **EUROPA**  **CM=185** | **GANYMEDE**  **CM=139** | **CALLISTO** |
| 2019-07-24-0412\_5-Io\_685NIR-Stack300-Wavelets2x10+3x5-Str0to128-Crop.jpg | 2019-07-24-0416\_0-Europa\_685NIR-Stack500-Wavelets2x10+3x5-Str0to128-Wavelets.png | 2019-07-24-0412\_5-Ganymede\_685NIR-Stack300-Wavelets2x10+3x5-Str0to128-Crop.jpg |  |
|  |  |  |  |
|  |  |  |  |
| 2019-07-24T0420.0\_Io\_WinJUPOSCapture-Mono-Smth.PNG | 2019-07-24-0416\_0-Europa\_WinJUPOSCapture-Mono-Smth.PNG | 2019-07-24T0420.0\_WinJUPOSCapture-Mono-Smth.PNG |  |

**SATURN**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-07-24-0452\_3-Saturn\_550GRN.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-07-24-0454\_6-Saturn\_650RED.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-07-24-0456\_1-Saturn\_685NIR.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-07-24-0458\_2-Saturn\_807NIR.avi | 0.1 | 70 | 50 | 2 | 640x480 |
| 2019-07-24-0503\_7-Saturn\_889CH4.avi | 0.999 | 80 | 50 | 2 | 640x480 |
| 2019-07-24-0511\_7-Saturn\_450BLU.avi | 0.1 | 50 | 50 | 2 | 640x480 |
| 2019-07-24-0515\_0-Saturn\_685NIR.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-07-24-0517\_1-Saturn\_685NIR.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-07-24-0522\_2-SaturnMoons\_685NIR.avi | 0.4 | 100 | 50 | 2 | 1280x960 |
| 2019-07-24-0524\_0-SaturnMoons\_685NIR.avi | 0.4 | 100 | 50 | 2 | 1280x960 |
| 2019-07-24-0525\_5-SaturnMoonsDark\_685NIR.avi | 0.4 | 100 | 50 | 2 | 1280x960 |

|  |  |
| --- | --- |
|  |  |
| 2019-07-24-0459\_5-Hill-Saturn-RGB-WhtBal-ClrSmth-Smth-Wavelets.jpg | 2019-07-24-0500\_7-Hill-Saturn-807-685-650-RGB-WhtBal-ClrSmth-Smth-Wavelets.jpg |
|  |  |
| 2019-07-24-0504\_5-Hill-Saturn-R(685)GB-RGB-WhtBal-ClrSmth-Smth-Wavelets.jpg | 2019-07-24-0503\_3-Hill-Saturn-889-650-450-RGB-WhtBal-ClrSmth-Smth-Wavelets.jpg |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 2019-07-24-0435\_4-Jupiter\_889CH4.png | 2019-07-24-0458\_2-Saturn-807NIR.png | 2019-07-24-0509\_4-Saturn\_685NIR-3Combined-Wavelets.png |
|  |  |  |
| 2019-07-24-0454\_6-Saturn\_650RED.png | 2019-07-24-0452\_3-Saturn\_550GRN.png | 2019-07-24-0511\_7-Saturn\_450BLU.png |
|  |  |  |
| 2019-07-24-0504\_2-Saturn\_All\_Red+NIR-Wavelets.png | 2019-07-24-0522\_2-SaturnMoons\_685NIR-Stack150-Wavelets4x10-Gam200pct-Crop-Annotated.png | 2019-07-24-0524\_0-SaturnMoons\_685NIR-Stack150\_Wavelets4x10-Gam200pct-Crop-Annotated.png |

**Data Disposition:** Raw data is zipped on the 4TB drive. Processed data is in appropriate project directories on the Astronomy thumb drive.

### 2019-July-28 (July 29 UT) SKUNK!

Last Updated 7/25/2019

I was just getting ready to image Jupiter when a baby skunk showed up. I shut down for the night. The next day I further investigated skunk deterrent methods. Most chemical systems don’t seem to work well. Automated sprinklers seem overly complex – and wet! So, given that skunks are nocturnal and bright lights are supposed to be a deterrent, I’ve planned the deployment of more and brighter temporary lights. This is very ironic given that astronomy requires darkness. However, I’ll set them up so they are facing outward from the telescope area and make them simultaneously switchable from a single power strip so that I can darken the whole area once imaging commences.

As part of the longer-term process, I will first install an outlet in the garden closet and plan on electrifying the shed and adding permanent external lights there.

## August

### 2019-Aug-12 (Aug 13 UT) Jupiter, Saturn, and Moons Videos

Last Updated 7/25/2019

Had intermittent clouds…

Seeing 4/5

Transparency varied 1/5 to 4/5

The only moon captured for Jupiter was Io. It is visible in both 889CH4 videos and in the 03:05.2 450BLU video. While the field coverage is wide enough in the 380NUV video, the moon is not detectable.

**JUPITER**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-08-13-0302\_4-Jupiter\_550GRN.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-08-13-0303\_9-Jupiter\_650RED.avi | 0.08 | 50 | 50 | 1 | 640x480 |
| 2019-08-13-0305\_2-Jupiter\_450BLU.avi **w/Io** | 0.08 | 50 | 50 | 1 | 640x480 |
| 2019-08-13-0311\_0-Jupiter\_450BLU.avi | 0.08 | 50 | 50 | 1 | 640x480 |
| 2019-08-13-0313\_3-Jupiter\_450BLU.avi | 0.08 | 50 | 50 | 1 | 640x480 |
| 2019-08-13-0320\_0-Jupiter\_380NUV.avi | 0.999 | 100 | 50 | 1 | 1280x960 |
| 2019-08-13-0325\_7-Jupiter\_685NIR.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-08-13-0326\_7-Jupiter\_685NIR.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-08-13-0328\_1-Jupiter\_807NIR.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-13-0330\_6-Jupiter\_889CH4.avi **w/Io** | 0.999 | 100 | 50 | 2 | 640x480 |
| 2019-08-13-0332\_8-Jupiter\_889CH4.avi **w/Io** | 0.999 | 100 | 50 | 2 | 640x480 |
| 2019-08-13-0335\_3-Jupiter\_889CH4\_DARK.avi | 0.999 | 100 | 50 | 2 | 640x480 |
| 2019-08-13-0336\_5-Jupiter\_380NUV\_DARK.avi | 0.999 | 100 | 50 | 1 | 1280x960 |

|  |  |
| --- | --- |
|  |  |
| 2019-08-13-0305\_4-Jupiter-RGB-WhtBal-ClrSmth-Smth-Wavelets.png | 2019-08-13-0319\_4-Jupiter-(807-685-650)-RGB-WhtBal-ClrSmth-Smth-Sat200pct-Wavelets.png |
|  |  |
| 2019-08-13-0316\_8-Jupiter-(807-550-380)-RGB-WhtBal-ClrSmth-Smth-Wavelets.png | 2019-08-13-0318\_4-Jupiter-(889-550-380)-RGB-WhtBal-ClrSmth-Smth-Wavelets.png |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 2019-08-13-0332\_8-Jupiter\_889CH4.png | 2019-08-13-0328\_1-Jupiter\_807NIR.png | 2019-08-13-0326\_2-Jupiter\_685NIR-Wavelets.png |
|  |  |  |
| 2019-08-13-0303\_9-Jupiter\_650RED.png | 2019-08-13-0302\_4-Jupiter\_550GRN.png | 2019-08-13-0309\_8-Jupiter\_450BLU-Stack400-Wavelets3x20+4x20-Wavelets.png |
|  |  |  |
| 2019-08-13-0320\_0-Jupiter\_380NUV.png |  |  |

**JOVIAN MOONS**

|  |  |  |
| --- | --- | --- |
| IO  CM=202 | IO  CM=198 | IO  CM=198 |
| 2019-08-13-331\_7-Io\_CH4-Stack206-Wavelets3x10+4x10-2X.jpg | 2019-08-13-0305\_2-Io\_450BLU-Stack100-Wavelets3x20+4x20.jpg | 2019-08-13-0305\_0\_Io\_WinJUPOSCapture-Mono-Blur.PNG |
|  |  |  |

It appears that Io is not resolved. A quick check of photometry – measurements of the ratio of Jupiter to Io brightness – results in numbers not consistent with the values obtained using the ST2000XM on 2019-09-10. In both the cases of 889CH4 and 450BLU, Io appears much dimmer (factors of 2-4). Though different gain settings and exposures were used for the two filters, gamma was set to be linear. It’s unlikely that clouds or atmospheric phenomena could cause an issue like this. And it’s non-physical for this to be a real variation. The only possibility I can come up with at this time is that I was centering Jupiter in the frames and not paying attention to Io. Perhaps many of the averaged frames were missing Io and thus reduced its average signal. This analysis was informal and wasn’t recorded in any spreadsheet or document.

**SATURN**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-08-13-0341\_6-Saturn\_685NIR.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-13-0342\_7-Saturn\_685NIR.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-13-0343\_8-Saturn\_685NIR.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-13-0345\_0-Saturn\_685NIR.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-13-0346\_3-Saturn\_650RED.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-13-0347\_6-Saturn\_650RED.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-13-0349\_0-Saturn\_550GRN.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-13-0350\_1-Saturn\_550GRN.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-13-0351\_5-Saturn\_450BLU.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-13-0352\_3-Saturn\_450BLU.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-13-0353\_3-Saturn\_450BLU.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-13-0354\_4-Saturn\_450BLU.avi | 0.05 | 50 | 50 | 2 | 640x480 |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 2019-08-13-0349\_8-Hill-Saturn-RGB-WhtBal-ClrSmth-Smth-Wavelets.png | 2019-08-13-0348\_6-Hill-Saturn-(NIR)GB-RGB-WhtBal-ClrSmth-Smth-Wavelets.png | 2019-08-13-0349\_2-Hill-Saturn-(NIR+RED)GB-RGB-WhtBal-ClrSmth-Smth-Wavelets.png |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 2019-08-13-0343\_3-Saturn\_685NIR.png | 2019-08-13-0347\_0-Saturn\_650RED.png | 2019-08-13-0345\_1-Saturn\_685NIR+650RED.png |
|  |  |  |
| 2019-08-13-0349\_5-Saturn\_550GRN.png | 2019-08-13-0352\_9-Saturn\_450BLU.png | 2019-08-13-0343\_3-Saturn\_685NIR-Stack1200-Wavelets1x10+2x20-2X-Stretch-Annotated.png |
|  |  |  |
|  |  |  |

**Data Disposition:** Raw data is zipped on the 4TB drive. Processed data is in appropriate project directories on the Astronomy thumb drive.

### 2019-Aug-13 (Aug 14 UT) Jupiter, Saturn, and Moons Videos

Last Updated 7/25/2019

I need to review the videos to see which ones had obscuration by clouds.

**JUPITER**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-08-14-0258\_8-Jupiter\_550GRN.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-08-14-0301\_1-Jupiter\_450BLU.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-08-14-0303\_3-Jupiter\_650RED.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-08-14-0310\_7-Jupiter\_685NIR.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-08-14-0313\_1-Jupiter+Io+Europa\_685NIR.avi | 0.1 | 50 | 50 | 1 | 1280x960 |
| 2019-08-14-0329\_0-Jupiter\_807NIR.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-14-0331\_8-Jupiter\_889CH4.avi | 0.999 | 100 | 50 | 2 | 640x480 |
| 2019-08-14-0334\_1-Jupiter\_889CH4.avi | 0.999 | 100 | 50 | 2 | 640x480 |
| 2019-08-14-0337\_2-Jupiter\_807NIR.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-14-0339\_5-Jupiter\_685NIR.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-08-14-0341\_8-Jupiter\_650RED.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-08-14-0344\_2-Jupiter\_550GRN.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-08-14-0346\_5-Jupiter\_450BLU.avi | 0.05 | 50 | 50 | 1 | 640x480 |
| 2019-08-14-0349\_7-Jupiter\_380NUV.avi | 0.2 | 100 | 50 | 2 | 640x480 |
| 2019-08-14-0351\_7-Jupiter\_380NUV\_DARK.avi | 0.2 | 100 | 50 | 2 | 640x480 |
| 2019-08-14-0352\_6-Jupiter\_889CH4\_DARK.avi | 0.999 | 100 | 50 | 2 | 640x480 |

|  |  |
| --- | --- |
|  |  |
| 2019-08-14-0322\_6-Jupiter-RGB-WhtBal-ClrSmth-Smth-Wavelets.png | From 2019-08-12 JALPO[[1]](#footnote-1) |

|  |  |
| --- | --- |
|  |  |
| 2019-08-14-0322\_6-Jupiter-RGB-WhtBal-ClrSmth-Smth-Wavelets.png | 2019-08-14-0326\_9-Jupiter-(807-685-650)-RGB-WhtBal-ClrSmth-Smth-Sat200pct-Wavelets.png |
|  |  |
| 2019-08-14-0334\_8-Jupiter-(807-GRN-NUV)-RGB-WhtBal-ClrSmth-Smth-Wavelets.png | 2019-08-14-0334\_7-Jupiter-(889-GRN-NUV)-RGB-WhtBal-ClrSmth-Smth-Wavelets.png |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 2019-08-14-0333\_0-Jupiter\_889CH4.png | 2019-08-14-0333\_1-Jupiter\_807NIR-Wavelets.png | 2019-08-14-0325\_1-Jupiter\_685NIR-Wavelets.png |
|  |  |  |
| 2019-08-14-0322\_6-Jupiter\_650RED-Wavelets.png | 2019-08-14-0321\_5-Jupiter\_550GRN-Wavelets.png | 2019-08-14-0323\_8-Jupiter\_450BLU-Wavelets.png |
|  |  |  |
| 2019-08-14-0349\_7-Jupiter\_380NUV.png |  |  |

**JOVIAN MOONS**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-08-14-0313\_1-Jupiter+Io+Europa\_685NIR.avi | 0.1 | 50 | 50 | 1 | 1280x960 |
| 2019-08-14-0315\_8-Io+Europa\_685NIR.avi | 0.05 | 75 | 50 | 1 | 640x480 |
| 2019-08-14-0319\_3-Ganymede\_685NIR.avi | 0.05 | 75 | 50 | 1 | 640x480 |
| 2019-08-14-0325\_1-Callisto\_685NIR.avi | 0.1 | 75 | 50 | 1 | 640x480 |

**SATURN**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Video File** | **Exposure** | **Gain** | **Gamma** | **Binning** | **Capture Area** |
| 2019-08-14-0411\_9-Saturn\_685NIR.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-14-0414\_0-Saturn\_685NIR.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-14-0416\_3-Saturn\_650RED.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-14-0418\_3-Saturn\_650RED.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-14-0420\_5-Saturn\_550GRN.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-14-0422\_6-Saturn\_550GRN.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-14-0424\_8-Saturn\_450BLU.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-14-0426\_9-Saturn\_450BLU.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-14-0429\_7-Saturn\_807NIR.avi | 0.05 | 50 | 50 | 2 | 640x480 |
| 2019-08-14-0436\_7-Saturn+Moons\_685NIR.avi | 0.05 | 70 | 50 | 2 | 640x480 |

**Data Disposition:** Raw data is zipped is archived on the 4TB drive. Processed data is in appropriate project directories on the Astronomy SD card.

### 2019-Aug-26 (Aug 27 UT) Jupiter and Moons Images

Last Updated 8/29/2019

|  |  |
| --- | --- |
|  |  |
| 2019-08-27\_0241\_4\_Jupiter\_467HeII-Crop.jpg |  |
|  |  |
| 2019-08-27\_0240\_9\_Jupiter\_486HIB-Crop.jpg |  |
|  |  |
| 2019-08-27\_0241\_8\_Jupiter\_501OIII-Crop.jpg |  |
|  |  |
| 2019-08-27\_0243\_7\_Jupiter\_889CH4-Crop.jpg |  |

I reconfigured the C11 to work at f/6.3 (~1760mm) with the ST2000XM camera so that I could do photometric imaging of Jupiter, Saturn, and their moons. The plate scale was measured with WinJUPOS to be 0.746 arcsec-pix-1 corresponding to a focal length of about 2.046 m. The focal length computed from the f/6.3 reducer should be about 1.764 m, giving a plate scale of 0.877 arcsec-pix-1. Given previous work with the C8 and the reducer, this gives strong evidence that the reducer functions at 0.70-0.73 rather than the stated 0.63.

I’d rate transparency as 2/5 and seeing as 3/5. The evening had patchy clouds that thickened and quickly blocked my observations. I was only able to obtain a single image in each band and used auto-dark to do so quickly. The exposures were long enough to establish necessary exposure durations and very rough relative photometry (). Measurements were conducted using MaximDL with aperture settings of [7,6,4] for Io (due to its proximity to Juptier), [10,6,4] for Europa, Ganymede, and Callisto; and [40,12,8] for Jupiter. Subsequent analysis was conducted in the spreadsheet *20190827UT-Photometry.xlsx*.

Table : Photometric Data (*20190827UT-Photometry.xlsx).*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Jupiter** | **Io** | **Europa** | **Ganymede** | **Callisto** |
| **BLU Avg Int (cts/sec)** | 8.40E+07 | 5.10E+04 | 4.97E+04 | 9.77E+04 | 2.73E+04 |
| **BLU SD (cts/sec)** | 6.31E+06 | 1.11E+04 | 1.69E+04 | 2.28E+04 | 1.02E+04 |
| **Frac SD** | 0.08 | 0.22 | 0.34 | 0.23 | 0.38 |
| **CH4 Int (cts/sec)** | 4.02E+05 | 3.22E+03 | 2.50E+03 | 4.21E+03 | 1.81E+03 |
| **CH4/BLU** | 0.005 | 0.063 | 0.050 | 0.043 | 0.066 |

**Blue Filter Performance**

The average of “blue” counts reported is the average of the 467HeIII, 486HIB, and 501OIII measurements. Note that the fractional standard deviation of ~0.29 for the moons was about 3.5 times larger than that of Jupiter (0.08). That implies that the variation between moon observations in different channels reflected statistics due to their signal being much lower than Jupiter’s signal.

I normalized the blue filter signals for each target by dividing by its 467HeII filter signal. Then to reduce scatter, I averaged that normalized signal across all targets. On average the 467HeII signal is greater than both the 486HIB and the 501OIII signals (). While the statistics aren’t great, the 95% confidence interval does support the conclusion. The total spread of about 50 nm in filter coverage is unlikely to include a sufficient color slope to create such a difference.

Another possibility is that the slope of the detector response plays a role. To see if this looks like a linear color slope, I fit a linear trend line (unweighted) in Excel and found a correlation coefficient of 0.97, which is highly suggestive. However, looking at the slope of the C8 transmission and the ST2000XM response in *System Performance and Flux Calibration.docx*, it appears that the former has a positive slope and the latter is relatively flat. Additionally, both the solar spectrum and the albedo spectra of the Jupiter and its moons have a positive slope. So, either the response of the C11 is *way* different than that of the C8 (unlikely) or there is a real difference in the filter transmission. It does not appear that I’ve done a quantitative assessment of the blue narrow band filters yet.

As an interesting note, the 467HeII filter is a custom filter with a slightly smaller diameter than the other two blue filters. This implies that the greater signal passing through is almost certainly a result of greater FWHM, greater transmission, or a combination of both.

Table : Average Signal through Blue Filters (*20190827UT-Photometry.xlsx).*

|  |  |  |
| --- | --- | --- |
| **Filter** | **/467HeII** | **95% Conf.** |
| 467HeII | 1.00 | 0.00 |
| 486HIB | 0.81 | 0.23 |
| 501OIII | 0.74 | 0.15 |

**Methane Absorption**

Normalizing the CH4 signal to the blue average signal provides indicates the magnitude of the methane absorption in Jupiter’s atmosphere. The average CH4/BLU ratio for the moons was 0.056 whereas for Jupiter it was 0.0048. Disregarding color slope differences between the moons and Jupiter, this means that Jupiter is only reflecting 8.6% of the light in the methane channel compared to the moons. This corresponds to an effective global optical depth of ~2.45. For a single reflecting layer model, this would be a one-way value of about 1.22. <<<Can I say anything about column depth using the overall band strength of the 889 nm band?>>>

**Instrument Magnitude**

To explore instrument magnitude, I computed took the visual magnitudes of Jupiter and its moons from WinJUPOS and computed a flux value as 2.5-mV (). This was divided into the blue average and CH4 counts measured. Instrumental magnitude was calculated as log2.5(mV Flux/counts). The instrumental magnitude for the blue counts is expected to be somewhat accurate due to the proximity of the blue and visual wavelengths. The instrumental magnitude for blue/visual wavelengths was 17.73±0.03 (95% confidence). The pertains to the average of the three narrow band blue filters.

Similarly, the instrumental magnitude was computed for the CH4 filter compared with WinJUPOS visual magnitudes. Due to the very different wavelengths, this was expected to show poor consistency due to albedo variations with wavelength between the moons. Jupiter was expected to be completely different due to its strongly absorbing atmosphere. Somewhat surprisingly, the instrumental magnitude average for the moons was rather consistent at 14.56±0.09 (95% conf.). This difference should be attributable first to the slope of the solar spectrum. Secondary effects are the instrument performance and moon albedos as a function of wavelength.

Table : Instrumental Magnitude (*20190827UT-Photometry.xlsx)*.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Jupiter** | **Io** | **Europa** | **Ganymede** | **Callisto** |
| **mV (WinJUPOS)** | -2.2 | 5.8 | 5.9 | 5.3 | 6.6 |
| **mV Flux** | 7.5070 | 0.0049 | 0.0045 | 0.0078 | 0.0024 |
| **mV Flux/BLU Avg** | 1.12E+07 | 1.04E+07 | 1.11E+07 | 1.26E+07 | 1.15E+07 |
| **Inst. Mag. (B,V)** | 17.71 | 17.63 | 17.70 | 17.84 | 17.75 |
| **mV Flux/CH4 Avg** | 5.35E+04 | 6.54E+05 | 5.58E+05 | 5.41E+05 | 7.64E+05 |
| **Inst. Mag. (CH4,V)** | 11.88 | 14.61 | 14.44 | 14.41 | 14.78 |

**Next Steps**

My goal is to do a spatially resolved, quantitative investigation of reflectance in different spectral bands of Jupiter. I received the 940NIR filter and on 9/1/2019 I replaced the 685NIR filter with the 940NIR filter for to this end. I also removed the f/6.3 focal reducer from the optic train at that time in order to improve spatial sampling.

A key factor in doing spatially resolved work is the need to do lucky imaging to improve the image quality sufficiently for meaningful co-registration. With the ‘2-minute’ limit on Jovian rotation and about 5 sec total intervals between images with the ST2000XM, I can get about 24 images without rotation compensation. I also need to decrease the plate scale by removing the focal reducer.

I also should be using averaged dark frames rather than auto-darks.

**Data Disposition:** Raw data is unaccounted for since the loss of an astronomy thumb drive in late 2019. Processed data is in appropriate project directories on the Astronomy SD card.

## September

### 2019-Sep-09 (Sep-10 UT) Jupiter and Moons Images

Last Updated 9/10/2019

Patchy clouds made these observations very non-photometric. Transparency 1-2/5. Seeing was quite good at 3.5/5.

|  |  |
| --- | --- |
|  |  |
| 2019-09-10-0156\_5-Jupiter-940NIR.png |  |
|  |  |
| 2019-09-10-0200\_1-Jupiter-889CH4.png |  |
|  |  |
| 2019-09-10-0211\_3-Jupiter-501OIII-Wavelets.png |  |
|  |  |
| 2019-09-10-0205\_9-Jupiter-486HIB.png |  |
|  |  |
| 2019-09-10-0208\_2-Jupiter-467HeII.png |  |
|  |  |
| 2019-09-10-0209\_2-Jupiter-NB-BLU-Wavelets.png |  |

|  |  |
| --- | --- |
|  |  |
| 2019-09-10-0158\_3-Jupiter-Hill-940NIRover889CH4.png |  |
|  |  |
| 2019-09-10-0158\_3-Jupiter-CH4Reflectance.png |  |

Process for reflectance image

* Flatten the background on each image
* Median filter each image (3x3)
* Exposure normalize each image
* Align images using the overlay method
* Divide 1.0x889CH4 by 2.46x940NIR. 2.46 being the average of the intensity ratios of the moons between 889 and 940. It accounts for things like solar spectral dependency, telluric absorption by the H2O band at 940nm, instrument system response spectral dependency, but inherently assumes constant albedo.

**Data Disposition:** Raw data is zipped is archived on the 4TB drive. Processed data is in appropriate project directories on the Astronomy SD card.

### 2019-Sep-12 (Sep-13 UT) Jupiter, Saturn, Moons, and M57 Images

Last Updated 9/10/2019

The sky was photometric (5/5) transparency. It’s possible there was some volcanic ash very high (need reference).

Seeing was very good 4/5.

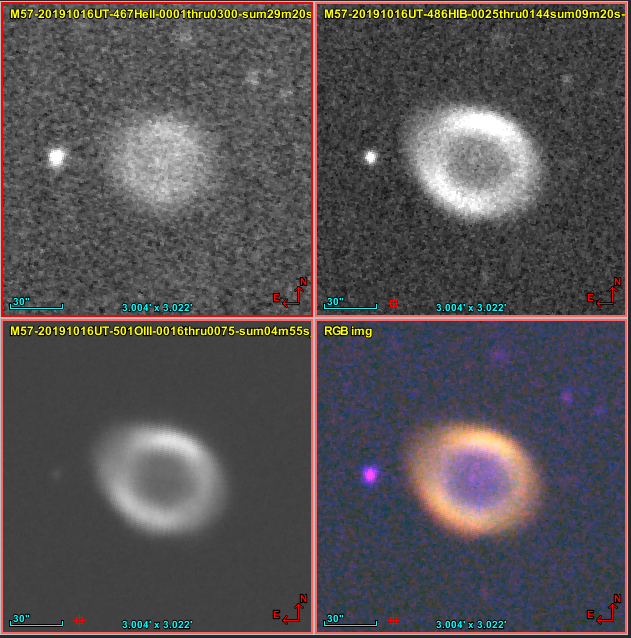
**Data Disposition:** Raw data is zipped is archived on the 4TB drive. Processed data is in appropriate project directories on the Astronomy SD card.

## October

### 2019-Oct-15 (Oct-16 UT) M57 Ring Nebula Narrow Band Images

Last Updated 10/23/2019

Transparency was 4/5 and seeing was 3/5. Tracking was pretty poor with a lot of consistent drift to the north (-y as the camera is mounted). This permitted exposures of only 5-10 seconds. If I can improve the polar alignment, I think I should be able to get to 30 second exposures.



M57-2800mm-BLUNarrowBand-3x3arcmin-2x2.PNG

HIB, OIII, and He II are rendered as red, green, and blue.

HeII 1.969E6

HIB 2.302E6

OIII 1.154E7

**Data Disposition:** Raw data is zipped is archived on the 4TB drive. Processed data is in appropriate project directories on the Astronomy SD card.

### Autumn 2019 Planning

Last Updated 4/4/2019

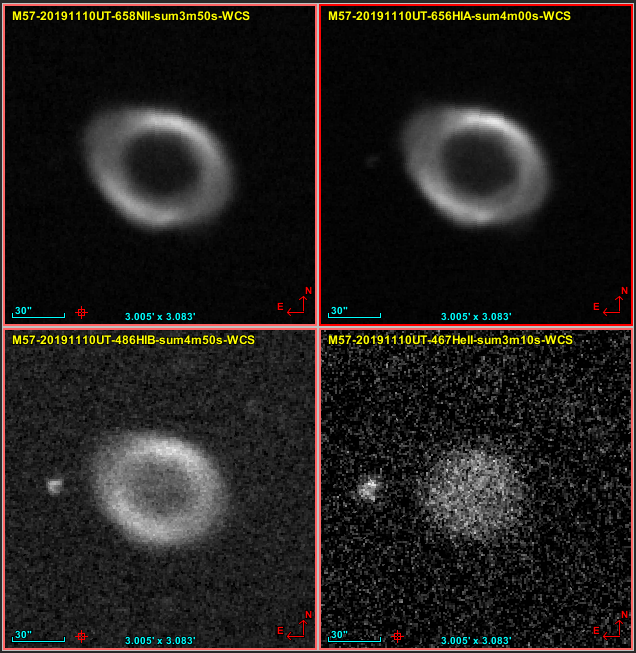
* Observations – Astro twilight begins around 6:10pm on Dec 3
  + Double Stars Video – C11
    - Mu Cyg (STF2822AB)
    - STF3050AB (HR9074) (new)
    - 36 And (STF73AB) (new)
    - Zet Aqr (STF2909) (new)
    - 53 Aqr (SHJ 345AB) (new)
    - Eta Cas (STF60) (transit 8:00pm)
    - STF3062
    - Iot Cas (StF262Aa-B)
    - Xi Cep (new)
    - STF202 (new)
  + Galaxies – 2000mm
    - M33 – Ha regions?
  + Nebulae
    - NGC6826 Blinking Planetary (Transit 6:40pm)
      * Linear imaging – Start with missing narrow blue bands: 467HeII, 486HIB, 501OIII, 656HIA, 658NII, 672SII
    - NGC7662 Blue Snowball Nebula (Transit 6:00pm)
      * Linear imaging – Start with missing narrow blue bands: 467HeII, 486HIB, 501OIII, 656HIA, 658NII, 672SII
  + Planets – 4500mm
    - **Neptune (transit 5:40pm)**
      * **ASI120MM 450BLU (WB Blue), 486HIB (weak 486CH4), 540CNT (moderate 543CH4), 550GRN (WB Green), 650RED (WB Red), 672SII (weak 668CH4), 685NIR (reference)**
      * **ST2000XM** experiment with filters, absorption, and color slopes (ASI120MM and *maybe* ST2000XM) [*Mendikoa et al.*, 2017; *Ordonez-Etxeberria et al.*, 2016]
        + Do 467HeII (continuum), 486HIB (CH4), 501OIII (continuum) and GRN540 (CH4) in the blue with 685NIR for reference
        + 656HIA (CH4 slope), 671SII (CH4 668 band center), 889CH4 (moons), and 940NIRwith 685NIR for reference
      * Moon imaging
        + Try to capture Nereid probably in 685NIR
        + Triton photometry
    - **Uranus (transit 8:35pm)**
      * **ASI120MM 450BLU (WB Blue), 486HIB (weak 486CH4), 540CNT (moderate 543CH4), 550GRN (WB Green), 650RED (WB Red), 672SII (weak 668CH4), 685NIR (reference)**
      * **ST2000XM** experiment with filters, absorption, and color slopes (ASI120MM and *maybe* ST2000XM) [*Mendikoa et al.*, 2017; *Ordonez-Etxeberria et al.*, 2016]
        + Do 467HeII (continuum), 486HIB (CH4), 501OIII (continuum) and GRN540 (CH4) in the blue with 685NIR for reference
        + 656HIA (CH4 slope), 671SII (CH4 668 band center), 889CH4 (moons), and 940NIRwith 685NIR for reference
      * Moon imaging
        + Try to capture all five moons, may need to use 889CH4 to reduce glare from Uranus
        + Moon photometry in a couple of bands
* Analysis
  + General code cleanup and consolidation
    - Astrophysical target data codes
    - Observational metadata codes
    - Observational data codes
    - Plot setup codes
    - **Start deleting organic spectroscopic and EW codes**
  + Photometry updates
    - **Numeric output**
    - Catalog data input
    - Response and transformation to standard filters
    - Variable stars and time series plots
    - Blackbody fit and Wein’s law temperature
  + Spectroscopy updates
    - **Make codes, including Vega and M57, more generic**
    - **Blackbody fit and Wein’s law temperature (new code)**
    - Spline fit for normalization (create class or generic routine)
    - Integration into EW Utils
    - **Line-based temperatures (H I and Na II)**
    - Consolidate EW plotting codes, e.g., EW vs line strength or N vs line strength (Jupiter and Vega…)
    - Balmer thermometer?
  + Jupiter spectroscopy and atmospheric vertical modeling – need to wrap up analysis at a clearly documented stopping point.
  + Should figure out what to do with individual star analyses, e.g., Vega, Castor
  + Galaxy composition gradient analysis
    - M31 Multispectral Analysis *ala* M33, M81, M101 etc.
    - Update M81 analysis with new narrowband data
  + Solar Eclipse Movies, ratio analysis, etc.
  + Questions for OPT
    - GoTo Mounts
    - Motorized Focuser

## November

### 2019-Nov-09 (Nov-10 UT) M57 & NGC 6826 Narrow Band Images

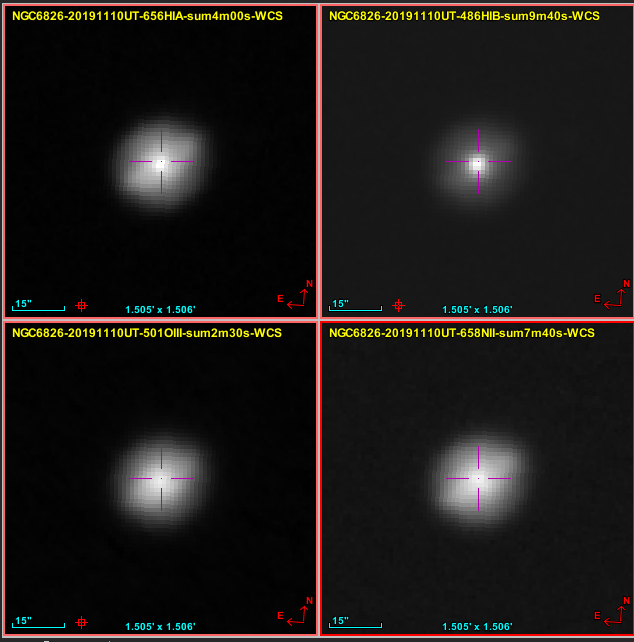
Last Updated 11/11/2019

Transparency was 4/5 and seeing was 3/5. I did a good polar alignment and tracking was quite good. I extended my snapshots from 5 to 10 seconds, but probably could have gone unguided for 20 or even 30 seconds.



M57-2800mm-20191110UT-NarrowBand-3x3arcmin-2x2.PNG

**Data Disposition:** Raw data is zipped is archived on the 4TB drive. Processed data is in appropriate project directories on the Astronomy SD card.



NGC6826-2800mm-20191110UT-NarrowBand-90x90arcsec-2x2.PNG

**Data Disposition:** Raw data is zipped is archived on the 4TB drive. Processed data is in appropriate project directories on the Astronomy SD card.

## References

Bouchez, A. H. (2004), Seasonal trends in Titan's atmosphere: Haze, wind, and clouds, 1364 pp.

Mendikoa, I., A. Sánchez-Lavega, S. Pérez-Hoyos, R. Hueso, J. F. Rojas, and J. López-Santiago (2017), Temporal and spatial variations of the absolute reflectivity of Jupiter and Saturn from 0.38 to 1.7 μm with PlanetCam-UPV/EHU, *Astronomy and Astrophysics*, *607*.

Ordonez-Etxeberria, I., R. Hueso, A. Sánchez-Lavega, and S. Pérez-Hoyos (2016), Spatial distribution of jovian clouds, hazes and colors from Cassini ISS multi-spectral images, *Icarus*, *267*, 34-50.

1. <http://alpo-j.asahikawa-med.ac.jp/kk19/j190812l1.jpg> retrieved 2019-09-19. [↑](#footnote-ref-1)