CELESTRON

Perspective on imaging

JUNE 19-20, 2013

THE PORTOFINO HOTEL & MARINA

REDONDO BEACH, CA

Photographing the Moon and the ISS

By Thierry Legault

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Photographing the whole Moon: basics

- Needs a DSLR at prime focus of the telescope
- The field of view depends on the telescope FL and the size S of the sensor
- The field shall be at least 0.55° for the whole Moon, ie FL < 100 S
- Example with APS-C sensor (24x15 mm):
  - FL < 2400 mm for a lunar crescent or quarter
  - FL < 1500 mm for a gibbous, Full Moon or Earthshine
- Example with 24x36 sensor:
  - FL < 3600 mm for a lunar crescent or quarter
  - FL < 2400 mm for a gibbous or Full Moon or Earthshine
- Longer FL or smaller sensor can be used, but through mosaics

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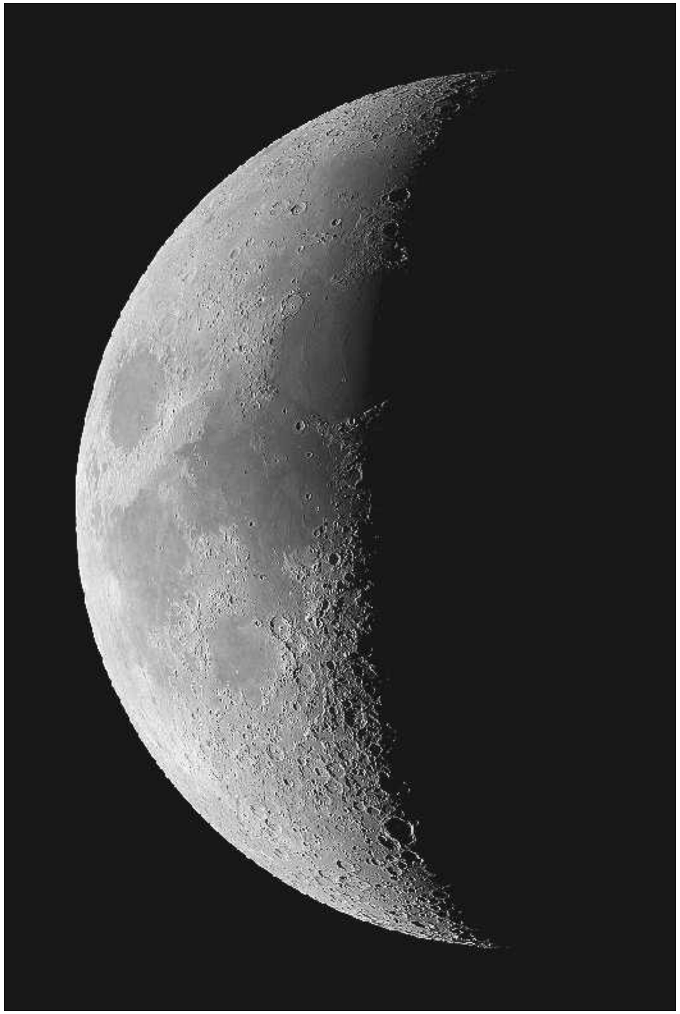
Photographing the whole Moon: field



Photographing the whole Moon: instrument

- Needs a telescope with a very good field coverage: Celestron Edge HD!

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Photographing the whole Moon: instrument

- A focal reducer may be necessary

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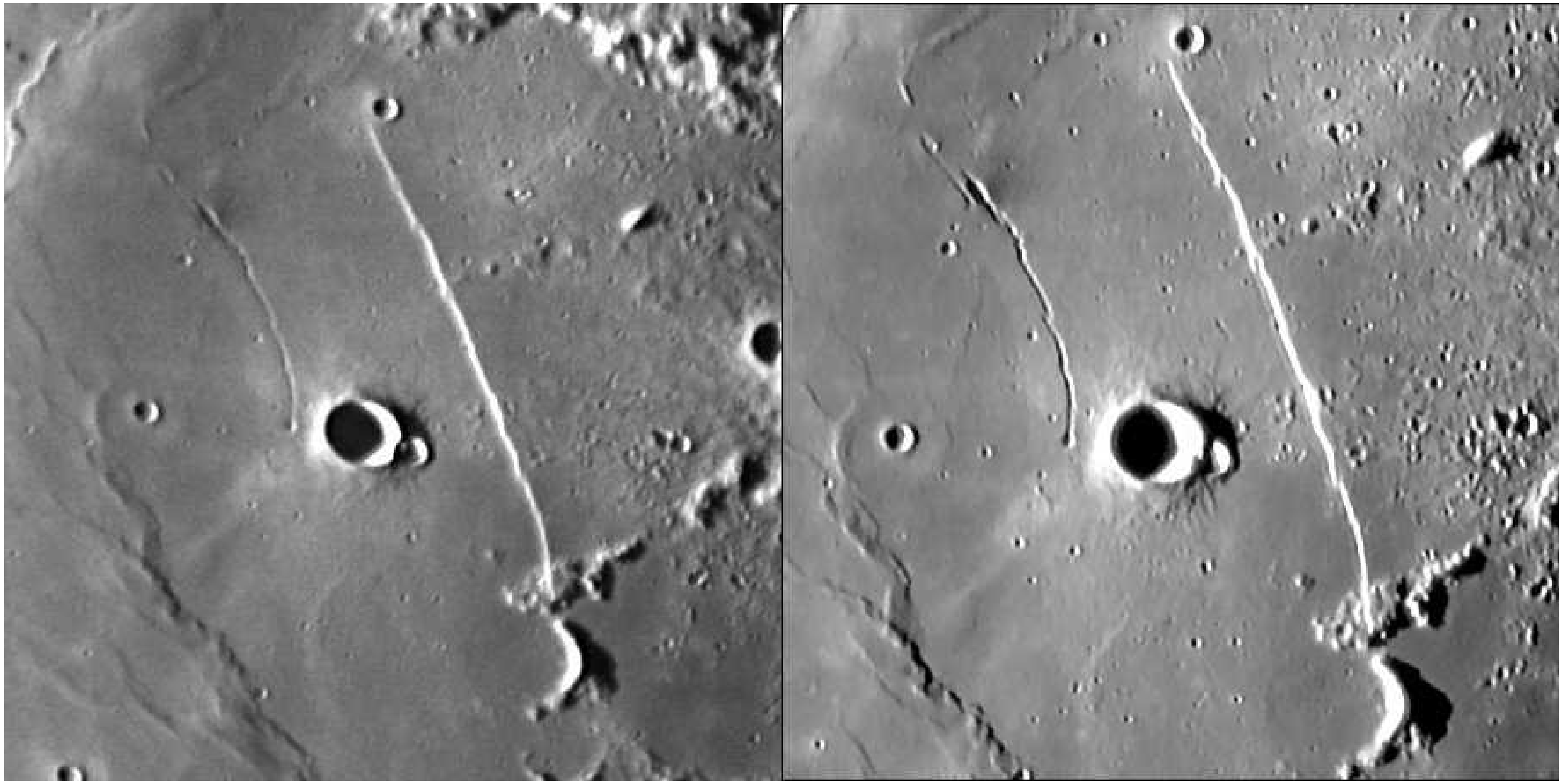
Photographing the Moon in high resolution: basics

- Needs a video camera (preferably B&W) and longer FL

- The final resolution depends on:
  - Telescope diameter
  - Optical quality
  - Focal length (sampling)
  - User adjustments: collimation, focusing
  - Thermal equilibrium
  - Seeing (turbulence)

Photographing the Moon in high resolution: the seeing



One of those images were taken with a 50$ webcam in average seeing conditions, the other with a CCD camera in very good seeing conditions

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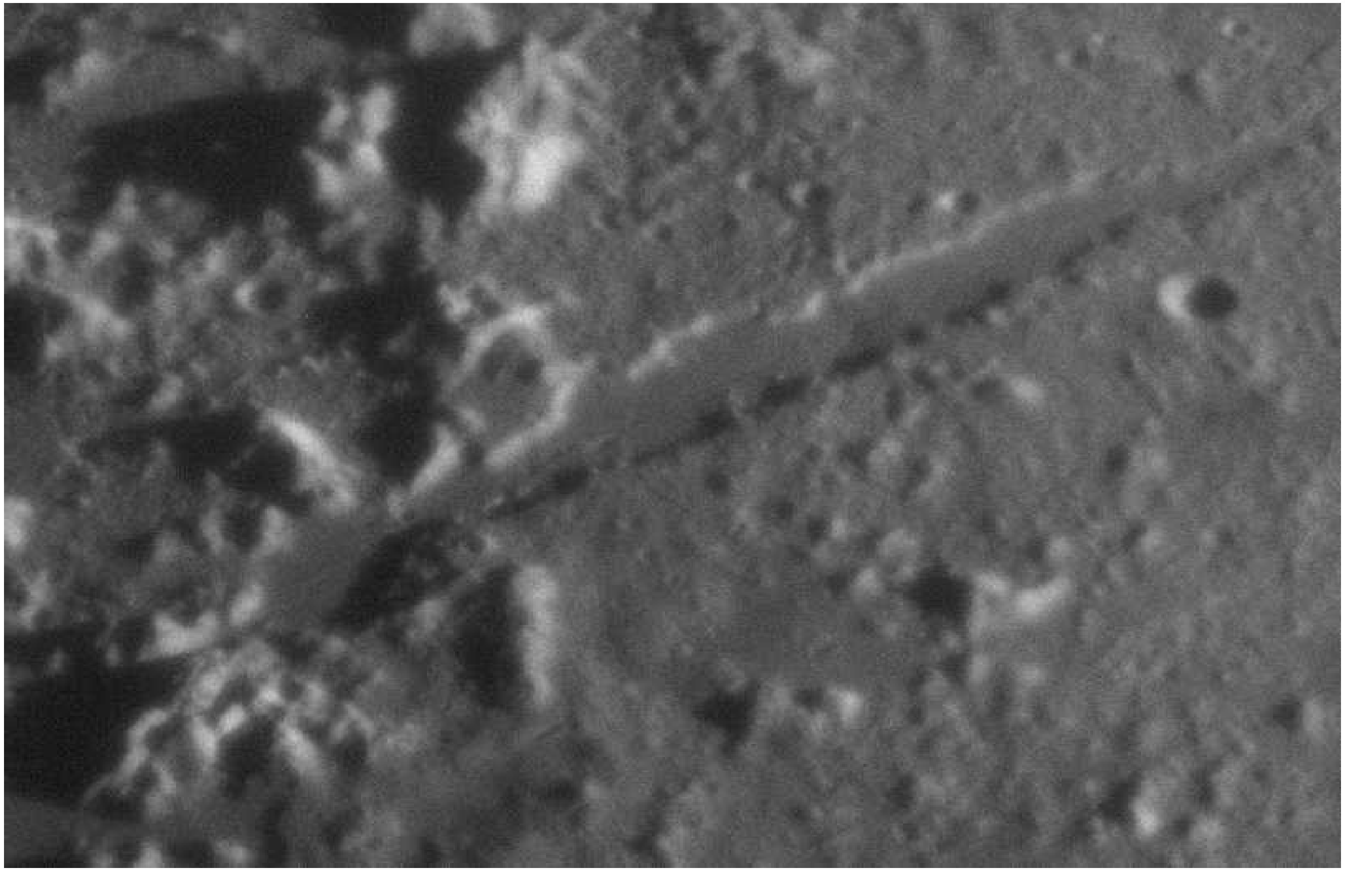
Photographing the Moon in high resolution: the seeing



The best and…

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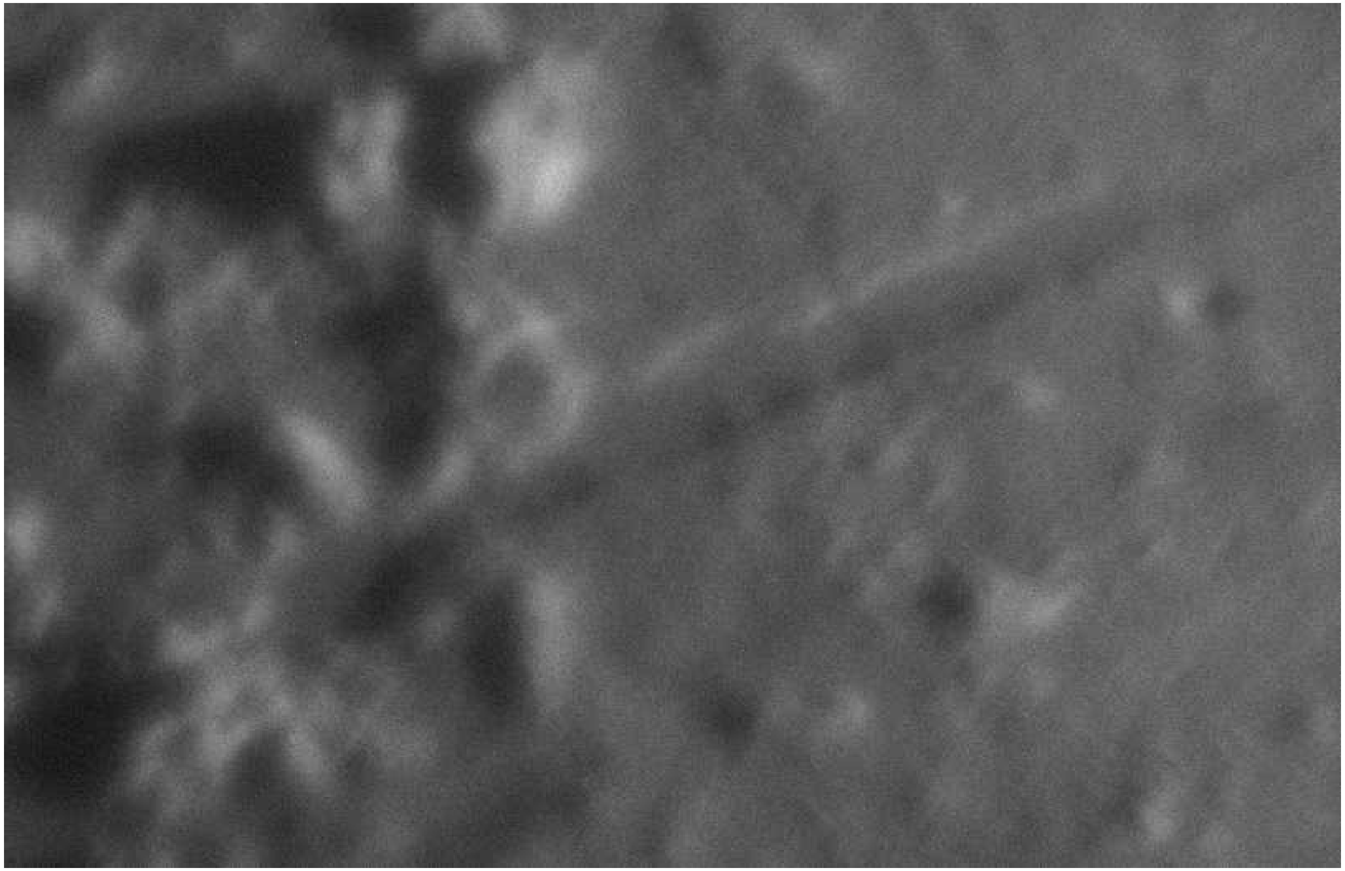
Photographing the Moon in high resolution: the seeing



…the worst image from the same 3-min video sequence:
<u>Because of turbulence, image selection is critical!</u>

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Photographing the Moon in high resolution: the seeing

- Turbulence shows many possible forms, depending on the behaviour of the atmosphere and the instrument used:
  - the images are fuzzy
  - the images are sharp but agitated and distorded

Both are generally mixed up, in variable amounts

- During an average night, only a small fraction (1% to 10%) of the images taken can be considered as very good (during a stable night, the percentage can rise to 20 to 40%, even more during exceptional nights)

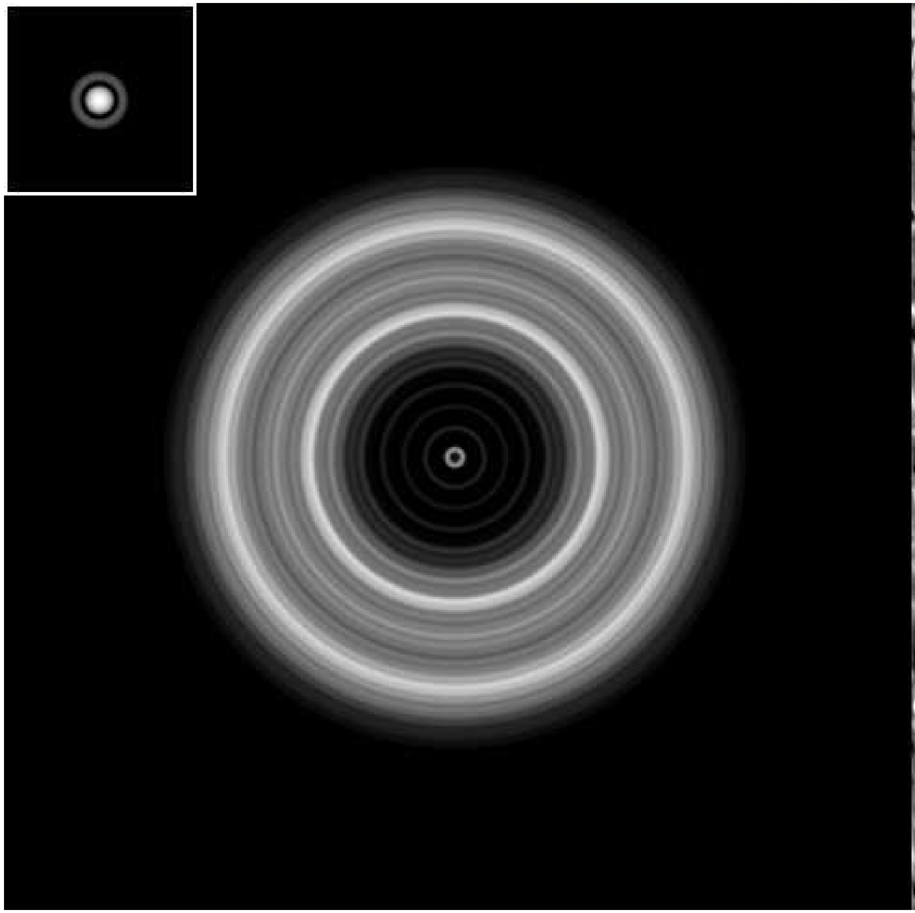
  - With CCD or DSLR, dozens of images are necessary to hope a few good ones
  - 1 minute of video at 30 fps give 1800 images!

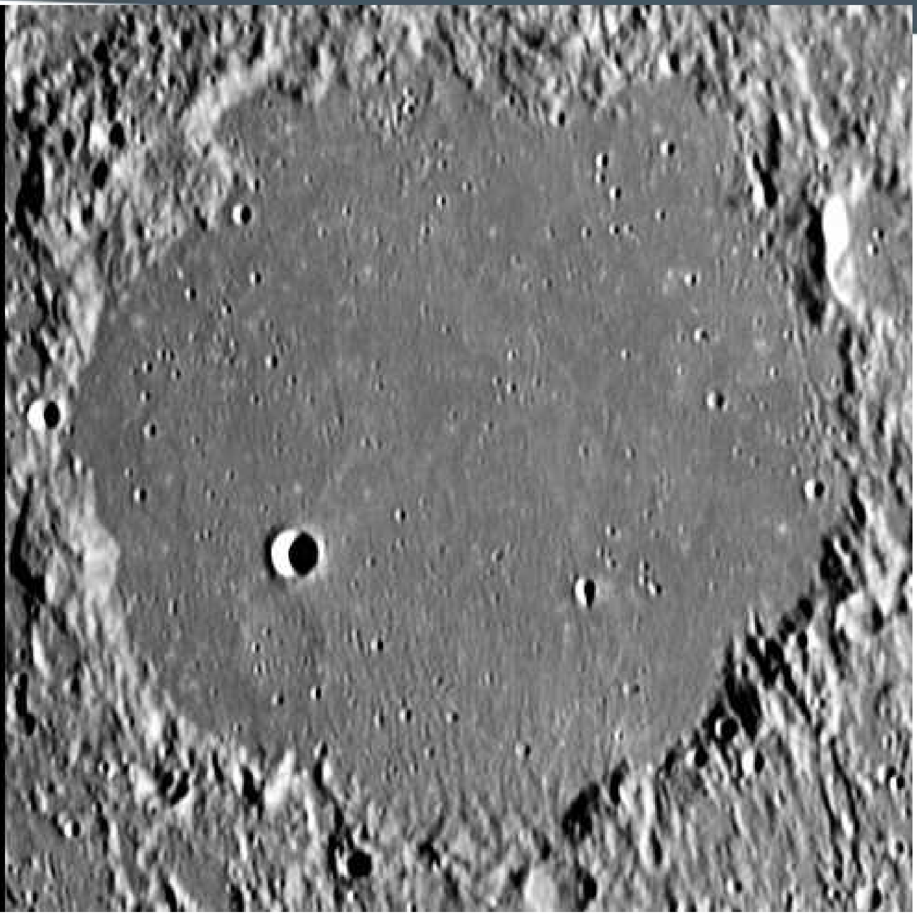
=> With turbulence, superiority of video is tremendous,
many nights unexploitable with DSLR or CCD are exploitable in video

Photographing the Moon in high resolution: the seeing

- At a given moment in a given site, the effective turbulence depends on:
  - The wavelength: a yellow or red filter helps to decrease it
  - The altitude of the Moon over the horizon:
    - Lights crosses a double thickness of air from zenith to 30°, and again from 30° to 15°
    - Prefer the First Quarter in Spring and Last Quarter in Fall, higher in the sky

Photographing the Moon in high resolution: collimation





The Good…

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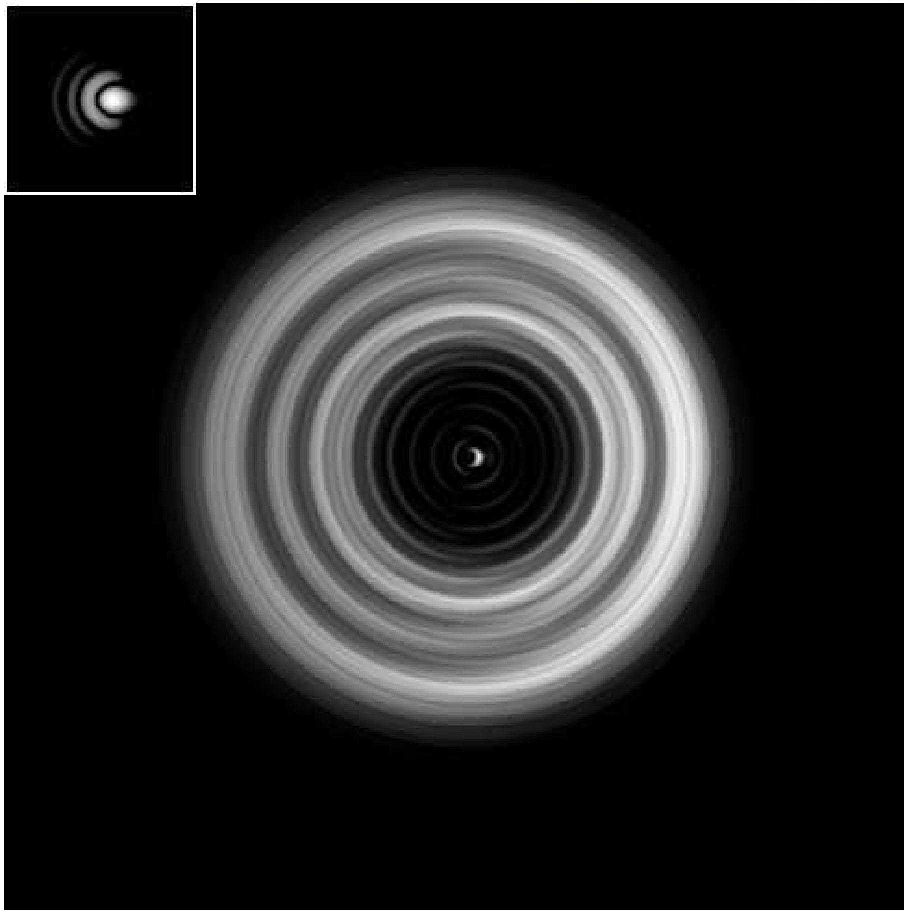
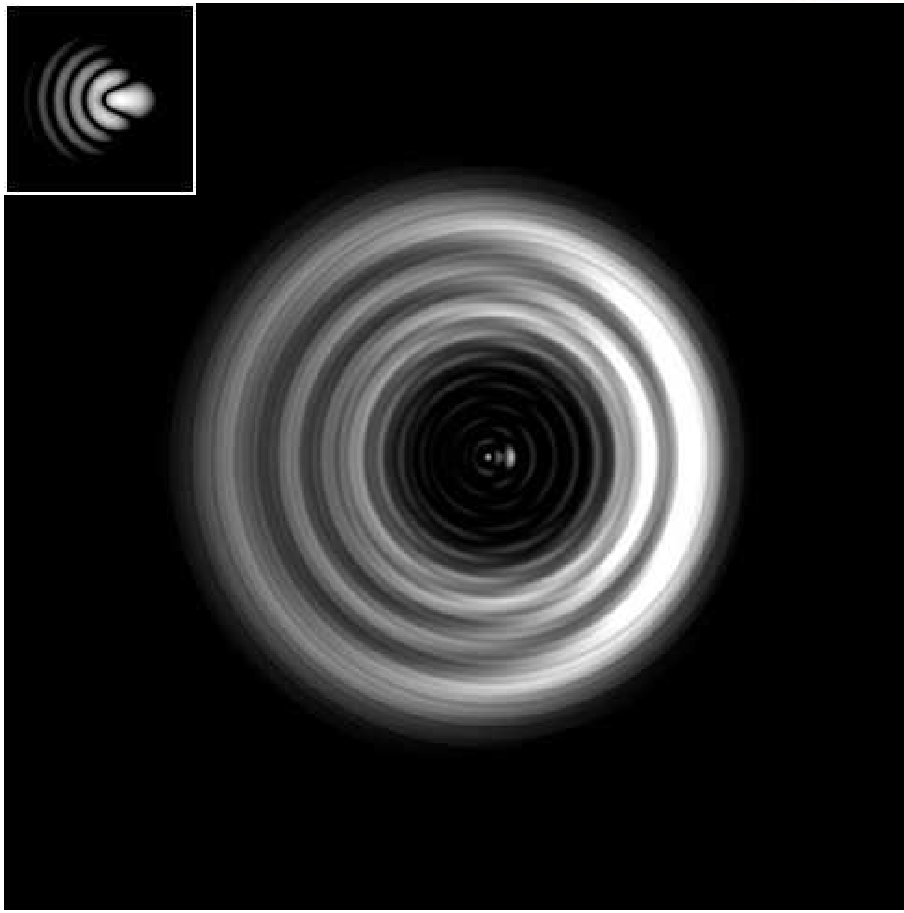
Photographing the Moon in high resolution: collimation



…The Bad…

Photographing the Moon in high resolution: collimation

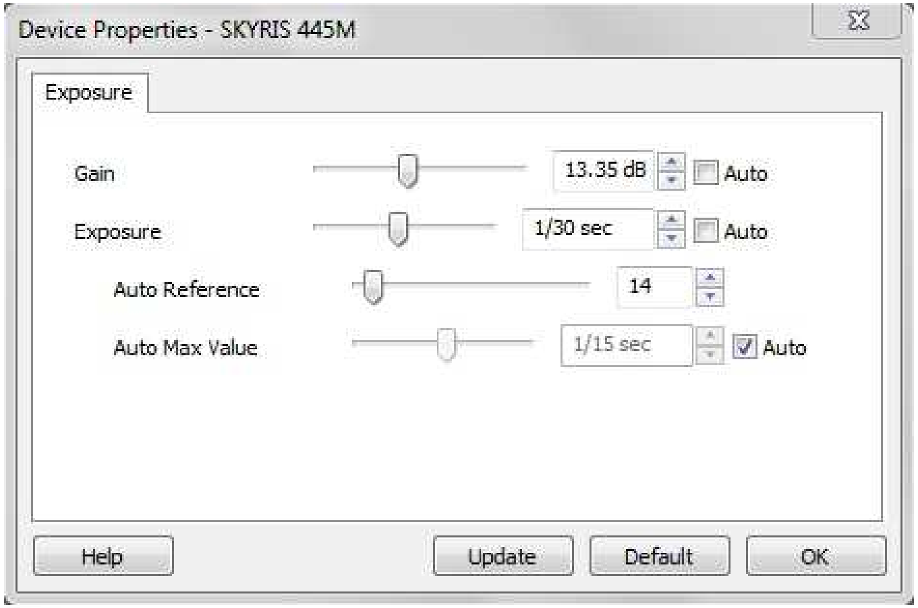



…and the Ugly

Photographing the Moon in high resolution: processing collimation

Camera parameters

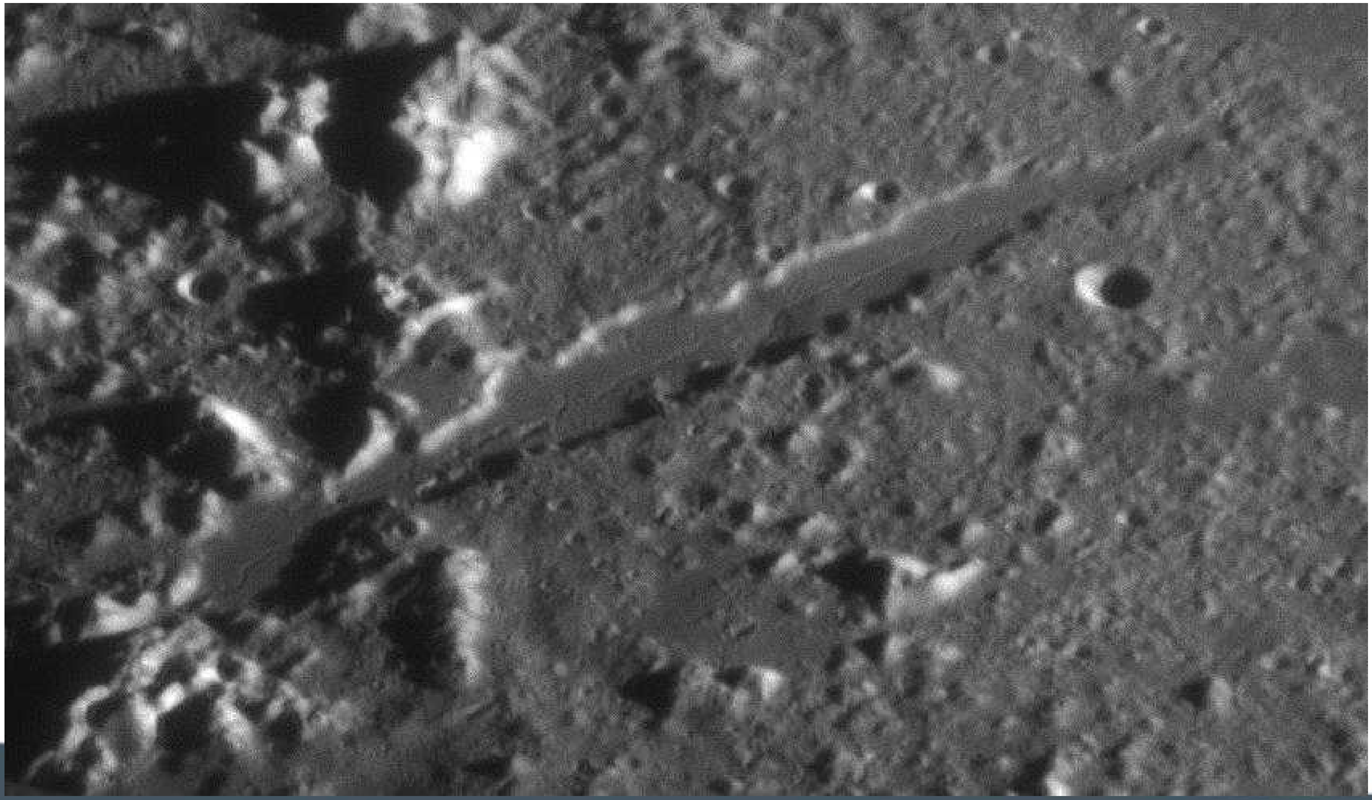
- Balance exposure time and gain for a good brightness without overexposition
- Higher gain allows shorter exp. time (good for turbulence)…but gives noisier images
- Lower gain gives less noisy images but increases exposure time



Photographing the Moon in high resolution: processing

Last generation (Autostakkert, Avistack, Registax) software make miracles!

- Generation 1: selection of best frames
- Generation 2: selection of best frames and turbulence de-distortion
- Generation 3: selection of best parts of frames and turbulence de-distortion



Generation 1

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Photographing the Moon in high resolution: processing

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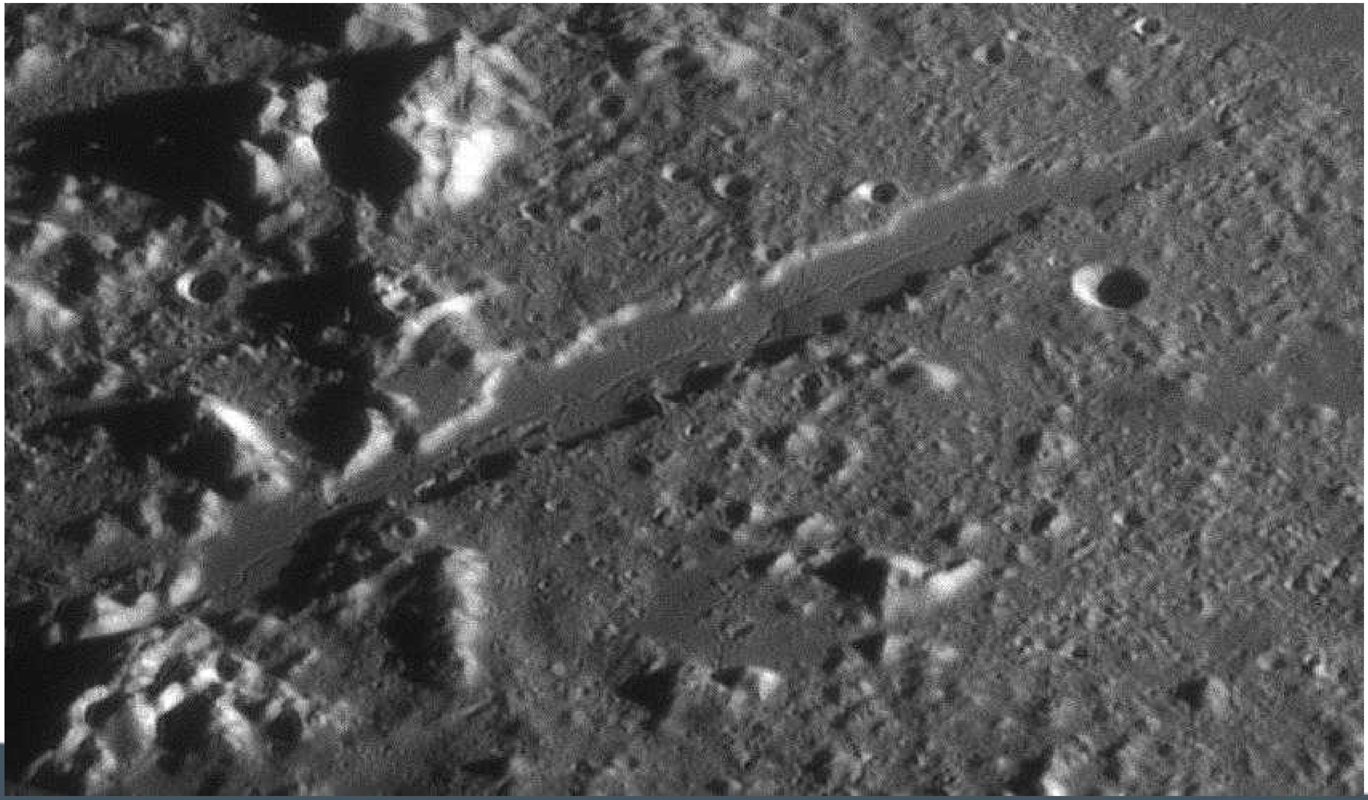

Generation 3

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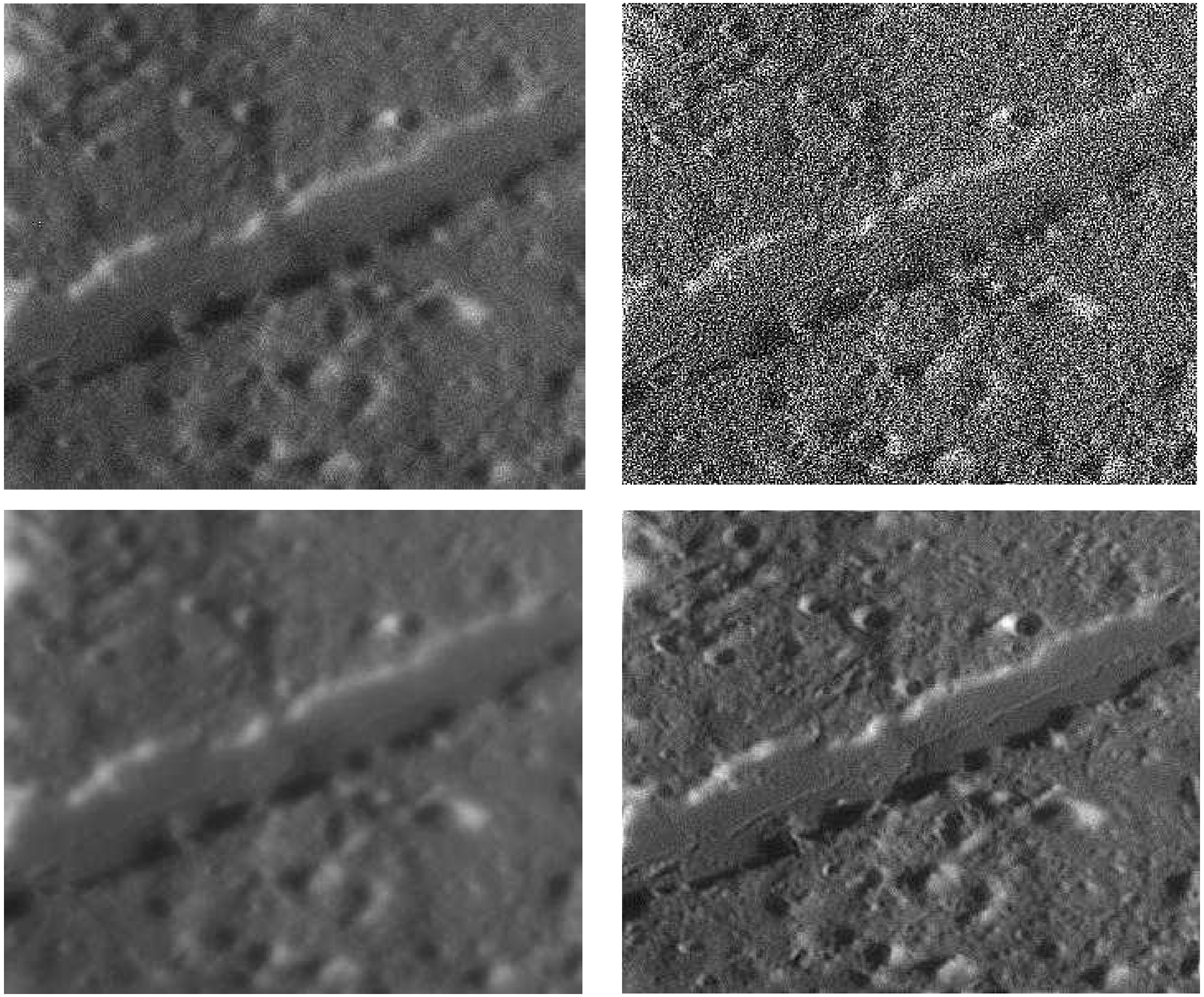
Photographing the Moon in high resolution: processing



Why combining many frames?
Because of noise!

Combining N frames decrease the noise by the square root of N

Photographing the Moon in high resolution: processing

<u>Beware of overprocessing!</u>

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Photographing the Moon in high resolution: focal length

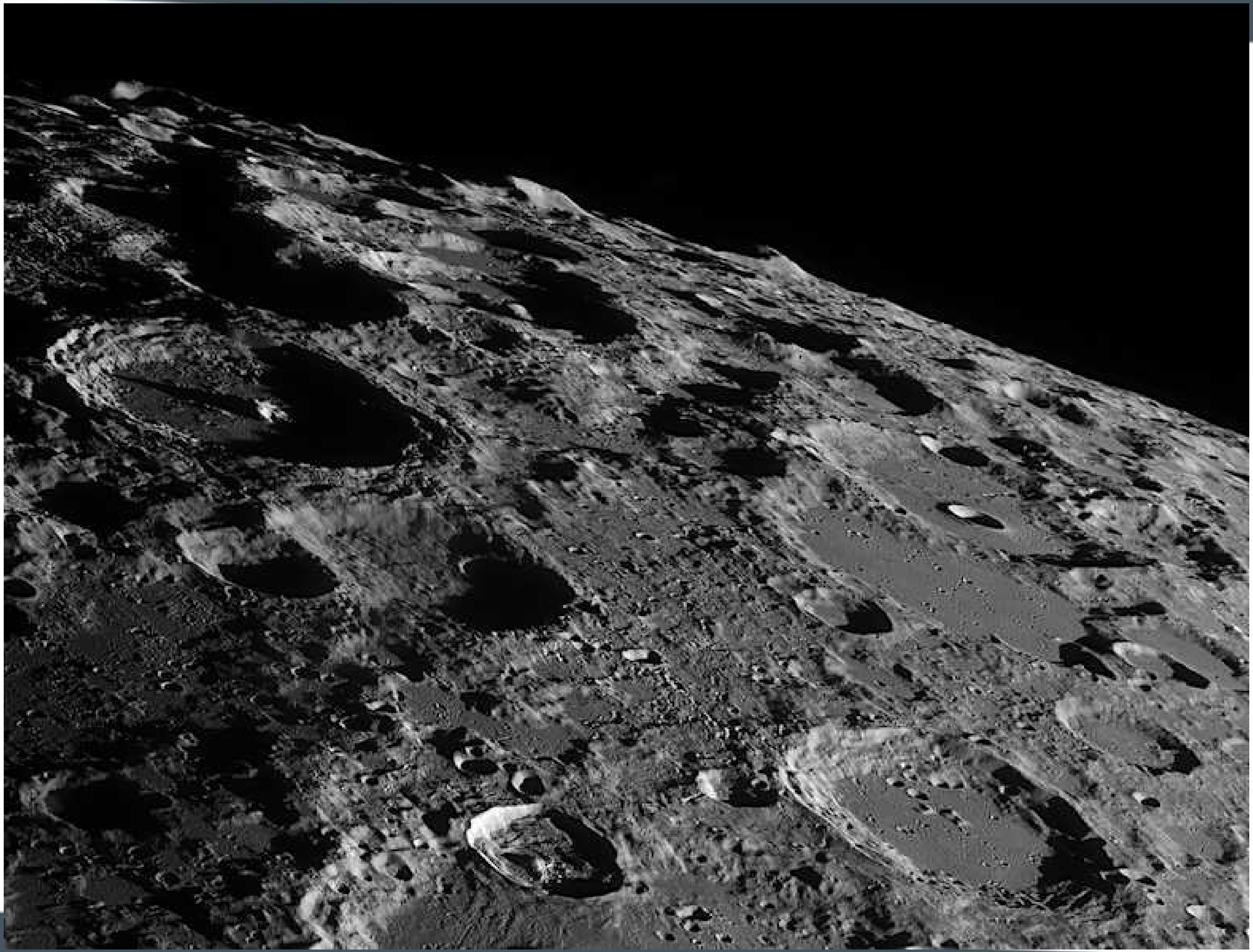
<u>Adjusting the FL for best resolution</u>

- FL too short: loss of details
- FL too long: loss of field of view and loss of light (=> exposure time increased)

- Sampling calculation: S = 206 p/FL (p is the pixel size)
  - Example: p = 5µm, FL = 2000 mm => S = 0.5 arcsec/pixel

- Best sampling rule: half the theoretical resolution (double stars) of the telescope
  - Example: 8’’ telescope offers a resolution of 0.65 arcsec => good sampling is about 0.3 arcsec/pixel => needs a Barlow 2x with 5 µm pixels

Photographing the Moon in high resolution: results



The International Space Station (ISS): basics

- Apparent size at zenith: similar to Jupiter
- Very bright parts (radiators, live modules), magnitude close to Venus
- Visible from all USA (orbital inclination 51.6°)
- Altitude: about 250 miles
- Very high speed: 17,000 mph,: 1.3°/s at zenith
- One orbit every 1.5 hour
- …but not always in Sunshine: only at twilight (Sun between 0° and -18°)

The International Space Station (ISS): HR photography

- Passages forecast calculated by Calsky or Heavens Above websites
- Photography in details with a telescope uses the same techniques as lunar imaging, with short exposure time (1 to 5 ms)
- The speed of the ISS makes manual tracking possible with a smooth mount but difficult: training on airplanes highly recommended!
- Tracking with goto mount by calculated trajectory is good for wide field imaging but not high resolution

The International Space Station (ISS): HR photography

ISS - Visible Passes

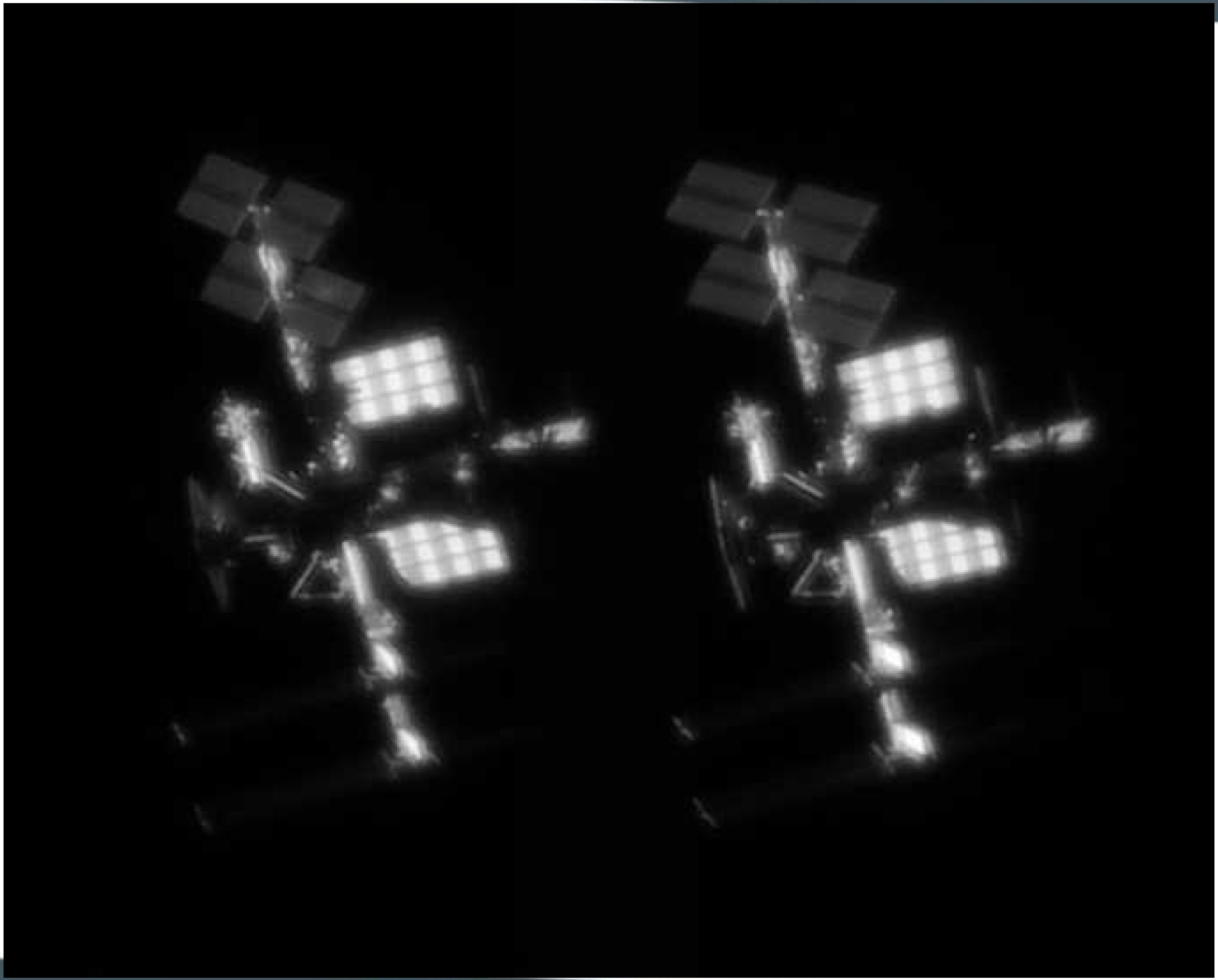
| Home | Info. | Orbit | Prev. | Next | Help |

Search period start: 00:00 Sunday, 31 October, 2010
Search period end: 23:00 Tuesday, 9 November, 2010
Observer's location: Paris, 48.8670°N, 2.3330°E
Local time zone: Central European Time (UTC + 1:00)
Orbit: 347 x 359 km, 51.6° (Epoch Oct 30)

Click on the date to get a star chart and other pass details.

Date	Mag	Starts			Max. altitude			Ends		
		Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
31 Oct	-2.0	17:49:50	10	SSW	17:52:13	23	SE	17:54:37	10	E
31 Oct	-3.5	19:24:23	10	WSW	19:27:08	72	WNW	19:27:08	72	WNW
1 Nov	-3.3	18:15:42	10	SW	18:18:35	55	SSE	18:21:05	13	ENE
1 Nov	-1.4	19:51:05	10	W	19:52:40	27	WNW	19:52:40	27	WNW
2 Nov	-3.6	18:42:09	10	WSW	18:45:05	73	NNW	18:46:33	26	ENE
2 Nov	-0.1	20:17:47	10	WNW	20:18:08	13	WNW	20:18:08	13	WNW
3 Nov	-3.3	17:33:21	10	SW	17:36:15	60	SSE	17:39:11	10	ENE
3 Nov	-3.1	19:08:48	10	W	19:11:40	49	N	19:11:57	46	NNE
4 Nov	-3.5	17:59:46	10	W	18:02:43	68	NNW	18:05:38	10	ENE
4 Nov	-1.9	19:35:24	10	WNW	19:37:18	32	NW	19:37:18	32	NW
5 Nov	-3.1	18:26:21	10	W	18:29:13	48	N	18:31:03	19	ENE
5 Nov	-0.5	20:01:52	10	WNW	20:02:38	16	WNW	20:02:38	16	WNW
6 Nov	-3.1	18:52:53	10	WNW	18:55:44	47	N	18:56:21	39	NE
7 Nov	-3.0	17:43:45	10	W	17:46:37	47	N	17:49:29	10	ENE
7 Nov	-2.9	19:19:15	10	WNW	19:21:38	50	NW	19:21:38	50	NW
8 Nov	-3.2	18:10:11	10	WNW	18:13:04	48	N	18:15:21	14	E
8 Nov	-1.2	19:45:34	10	WNW	19:46:56	24	W	19:46:56	24	W
9 Nov	-3.6	18:36:29	10	WNW	18:39:26	70	NNE	18:40:41	30	E
9 Nov	0.0	20:12:02	10	W	20:12:16	12	W	20:12:16	12	W

The International Space Station (ISS): HR photography



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The International Space Station (ISS): transits basics

- Lunar and solar transits forecast calculated by Calsky website
- Duration of transit: 0.5s to a few seconds
- Visibility band width: 3 to 10 miles
- For solar transits, use a safe solar filter (preferably with high transmission such as Baader Astrosolar photo density, for the shortest exposure time)
- Use a DSLR in continuous shooting mode or a video camera

The International Space Station (ISS): transits

Select satellite events for your location

☑ **Show satellite passes**

☐ **Show invisible passes:** Calculate all passes, day or night, even if not optically visible

Auto ▾ **Minimum elevation:** Show satellite passes with at least this altitude above horizon

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☑ **Close fly-bys of satellite with sun, moon, planets, and stars**

Maximum angular separation from Sun/Moon/planets/stars for close encounters: ○ 1½° ○ 5° ○ 10° ○ 15°

or

Maximum distance to center line: ○ 5 km ○ 10 ○ 15 ○ 25 ○ 50 ○ 100 ◉ 250 km

go!

☐ **Only transits:** Calculate and display sun/moon/planet/star **crossers only, but no close encounters**

☑ **Only Sun/Moon events:** Display **transits/encounters only with the Sun or Moon**, but not with planets and stars

☐ **Satellite must be illuminated:** Display only transit/encounter events where the satellite is illuminated by the sun and hence visible; e.g. the satellite can be detected as a dark silhouette against the moon

☐ **Hide 'double' solar transits** (events/geographic places with passing of the satellite in front of the Sun on consecutively passes)

☐ **Mirror hemisphere images:** the satellite tracks are shown with reversed east and west directions

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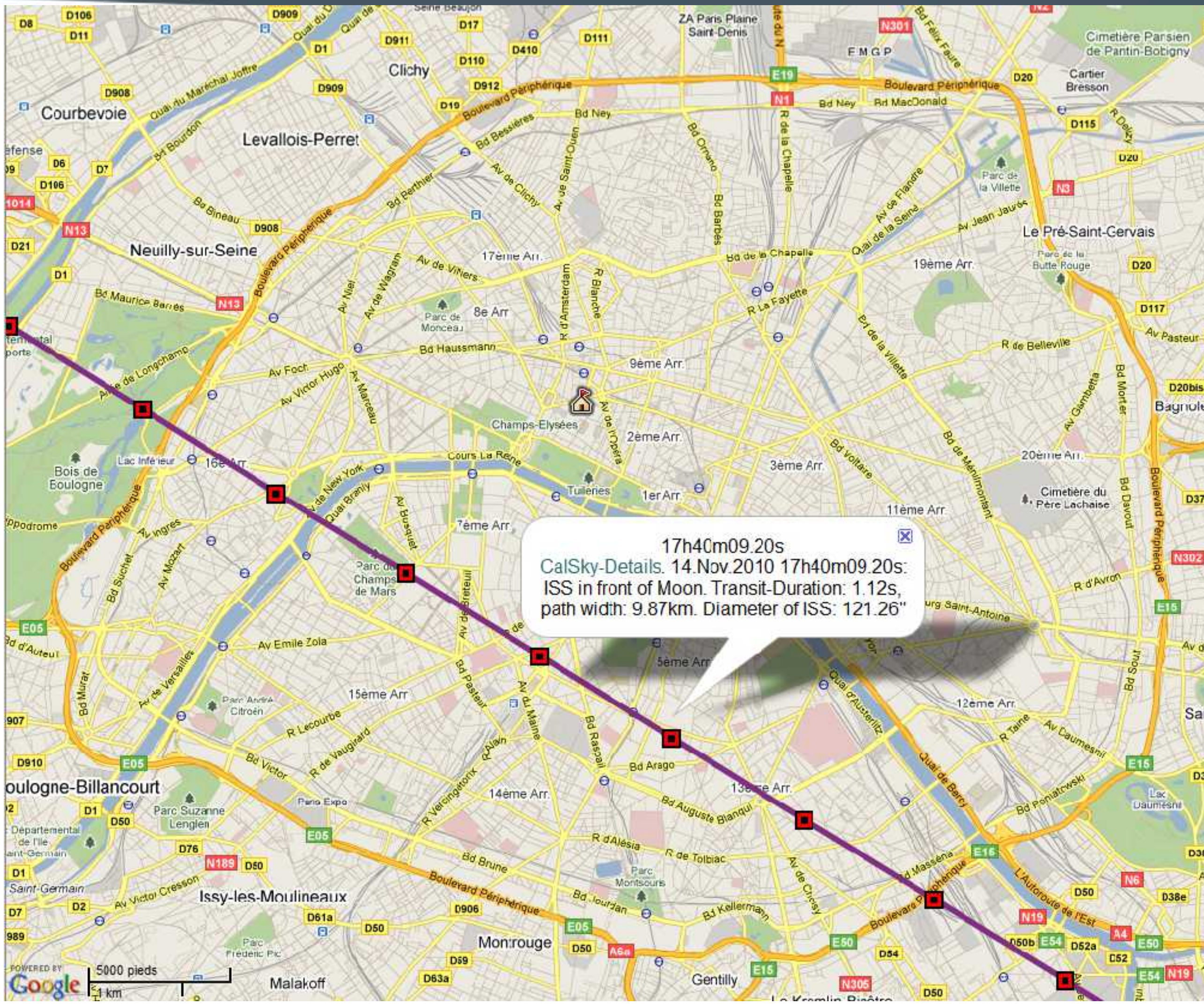
The International Space Station (ISS): transits

Sunday 14 November 2010

Time	Object (Link)	Event
12h52m04.48s	ISS	Close to Sun. Separation=13.302° Position Angle=337.8° Angular diameter=30.9" size=73.0m x 44.5m x 27.5m Satellite at Azimuth=191.2° S Altitude= 34.7° Distance=600.0 km In a clock-face concept, the satellite will seem to move toward 9:51 Angular Velocity=36.4'/s Centerline, closest point →Map: Longitude= 1°23'00" E Latitude=+51° 46'57" (WGS84) Distance=330.51 km Azimuth=348.6° NNW Path direction= 51.4° NE ground speed=8.306 km/s width=30.5 km max. duration=1.3 s Orbit source: NASA predicted orbit
17h39m00s	ISS →Ground track →Star chart	Appears 17h34m04s 1.1mag az:289.8° WNW horizon Culmination 17h39m00s -3.1mag az:208.2° SSW h:49.7° distance: 458.2km height above Earth: 356.0km elevation of sun: -5° Disappears 17h43m52s -0.8mag az:126.5° SE horizon Time uncertainty of about 1 seconds
17h40m09.11s	ISS	Crosses the disk of Moon. Separation=0.166° Position Angle=203.8°. Transit duration=0.83s Angular diameter=27.3" size=73.0m x 44.5m x 27.5m Satellite at Azimuth=148.3° SSE Altitude= 29.1° Distance=677.6 km Magnitude=-3.0mag In a clock-face concept, the satellite will seem to move toward 7:31 Angular Velocity=26.2'/s Centerline, closest point →Map: Longitude= 2°18'40" E Latitude=+48° 51'02" (WGS84) Distance=2.53 km Azimuth=211.8° SSW Path direction=121.8° ESE ground speed=8.345 km/s width=9.9 km max. duration=1.1 s Sun elevation=-5° Elongation from Sun=101° Time uncertainty of about 1.1 seconds Orbit source: NASA predicted orbit

The International Space Station (ISS): transits



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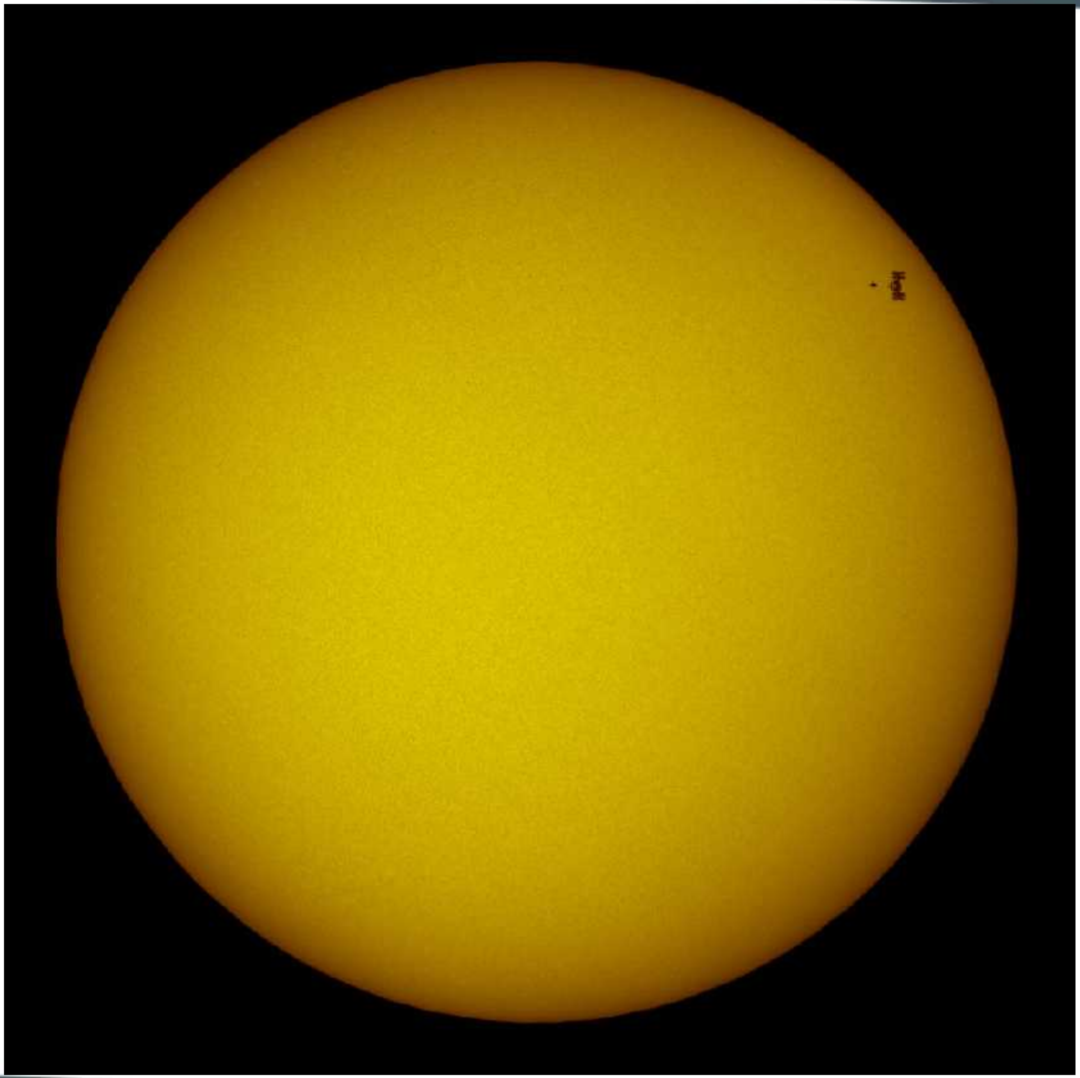
The International Space Station (ISS): transits



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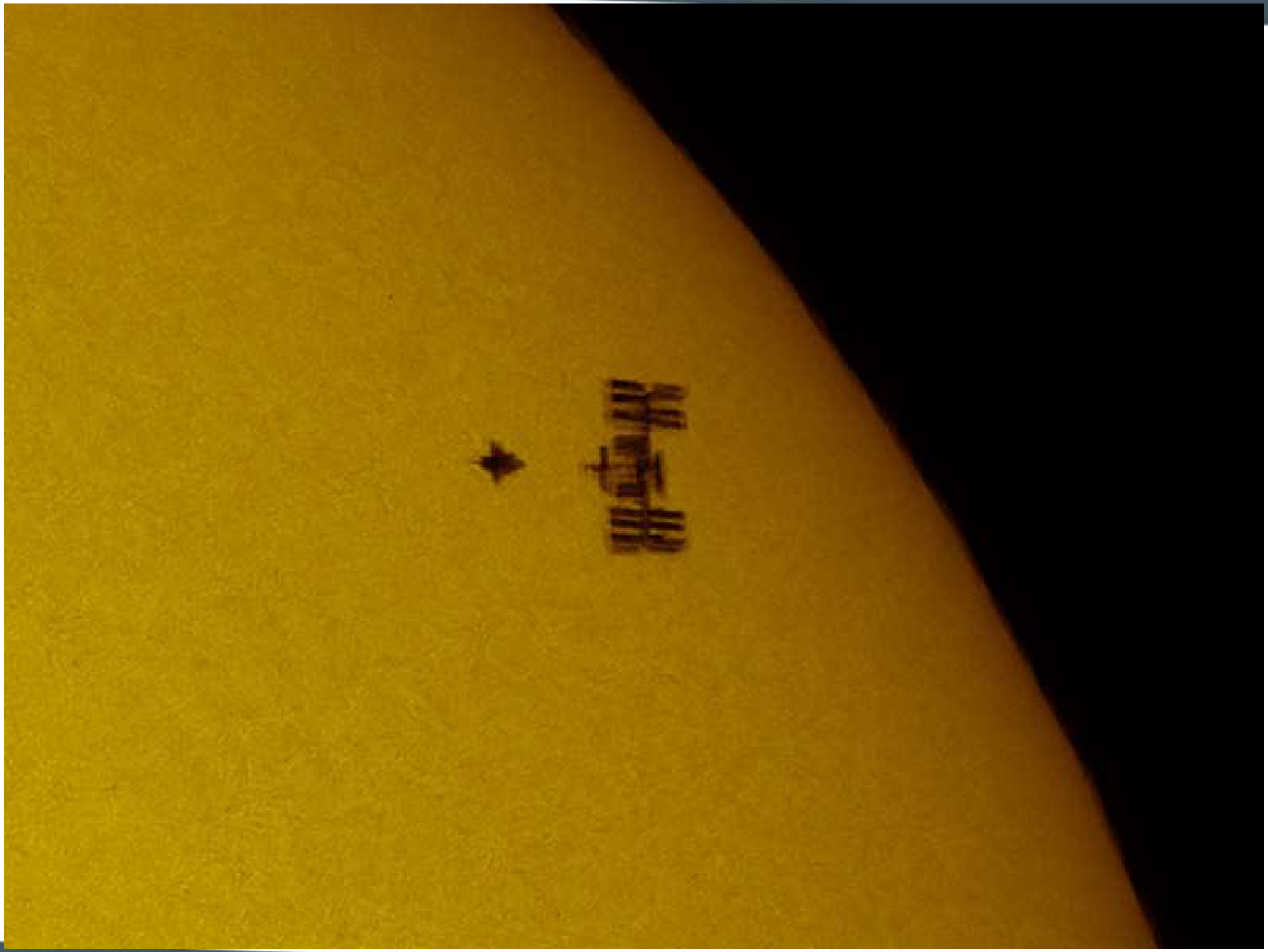
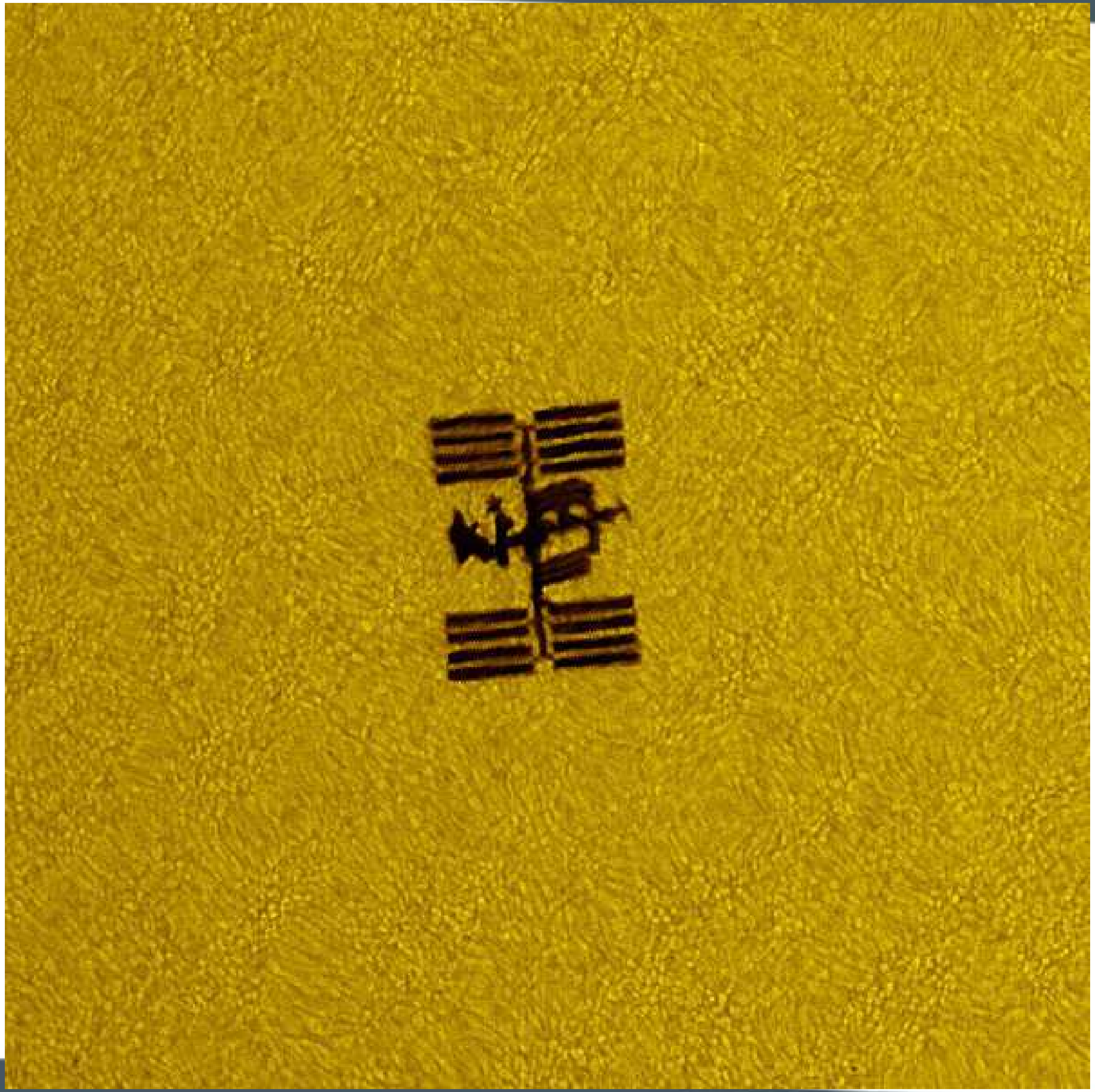
The International Space Station (ISS): transits



The International Space Station (ISS): transits



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The International Space Station (ISS): transits

Thank you!