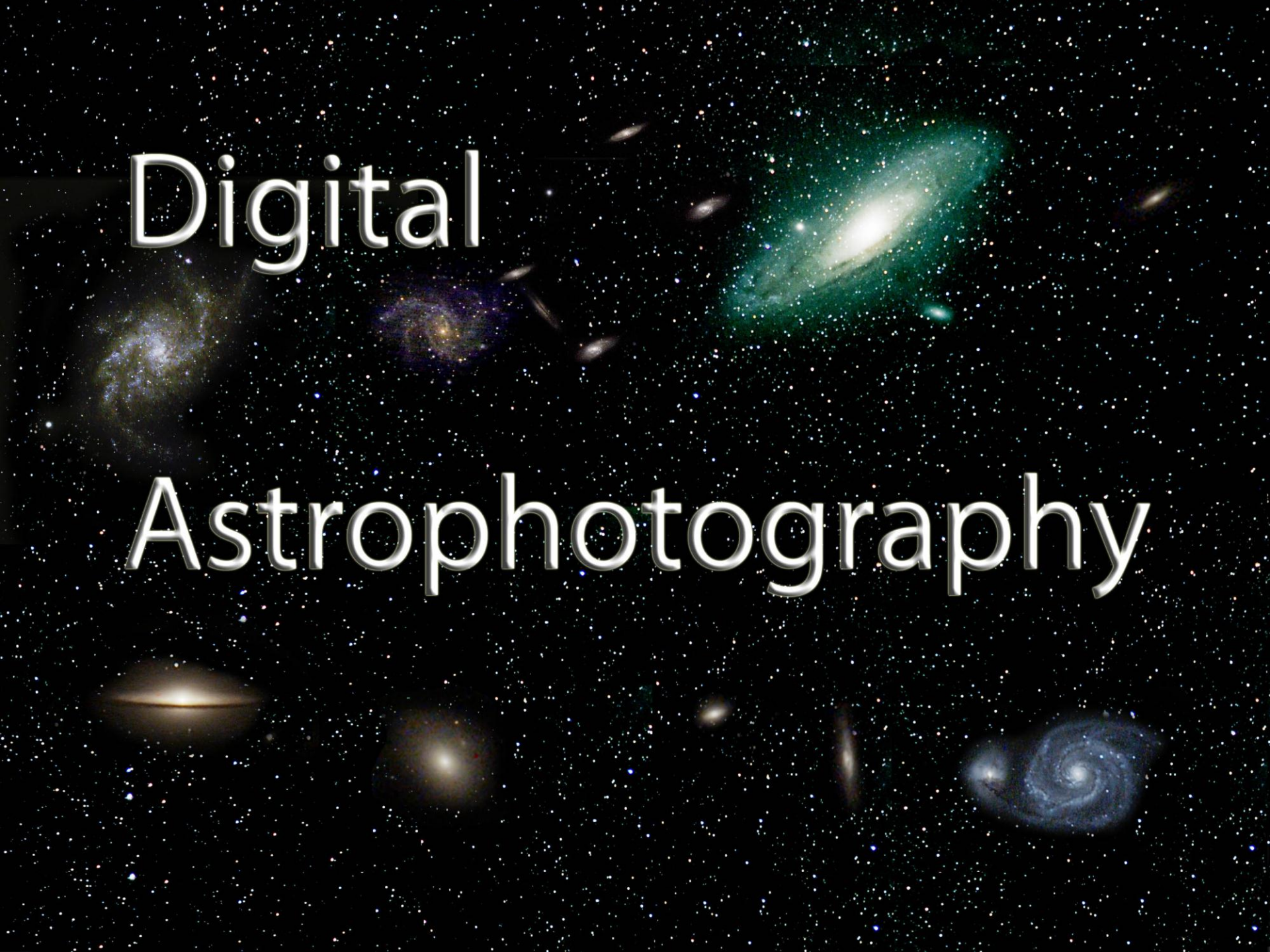




Digital

Astrophotography

Astrophotography Subjects

- ▣ Solar and Lunar
 - Bright , relatively large objects
 - Short exposures – special cameras not required
 - Solar photography requires special filters
- ▣ Planets and Comets
 - Bright to very dim
 - Planets are very small objects – small angular size
 - Requires high magnification
 - Subject to image degradation from atmospheric turbulence
- ▣ Deep Sky objects
 - Large to very small angular size
 - Very low surface brightness
 - Very long exposures
 - Special processing techniques required

Amateur Astrophotography

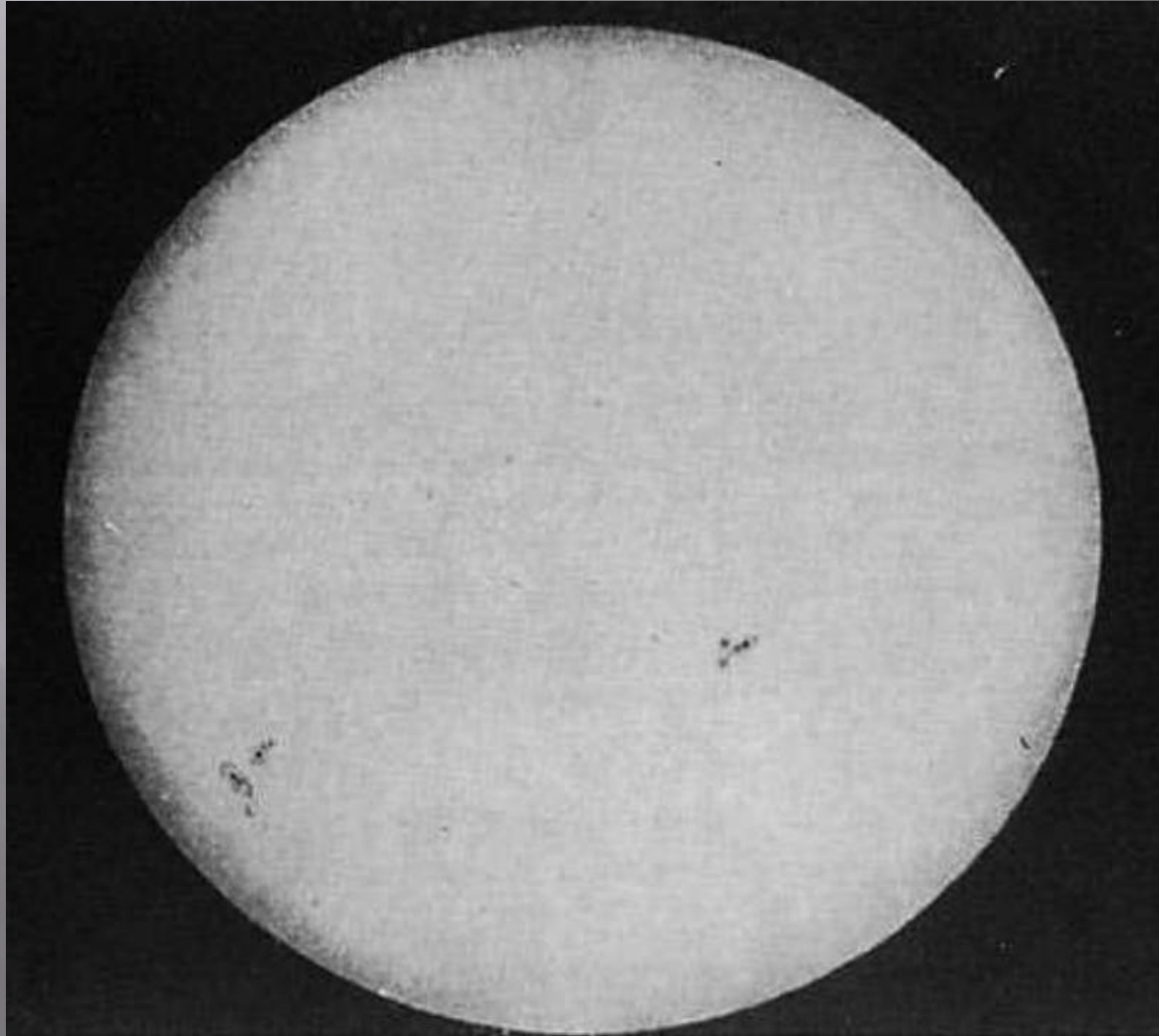
- ▣ Deep Sky photography requires long focal length telescope lens and tracking mount
- ▣ Amateur Astrophotography setup can cost from \$2000 to \$3000 up to several 10s of thousands
- ▣ Each deep sky photography can consume several hours or more to capture and process

History of Astrophotography

- ▣ 1840 - First Successful Astrophotograph
 - John William Draper
 - 20 Min exposure of Moon
- ▣ 1850 - First Star Photo
 - John Adams Whipple & Wm. Cranch Bond
 - 100s exposure of Vega
 - 38cm Harvard Refractor
- ▣ 1880 – First Photo of Orion Nebula
 - 51min exposure
 - 28 cm Alvan Clark Refractor on Equatorial Mount
- ▣ 1879 - Photo of Jupiter
- ▣ 1881 – First Successful Image of a Comet
 - 30 Min Exposure
 - 50cm f/3 instrument

Daguerreotype of Sun

Fizeau and Focault
1845 Paris Observatory

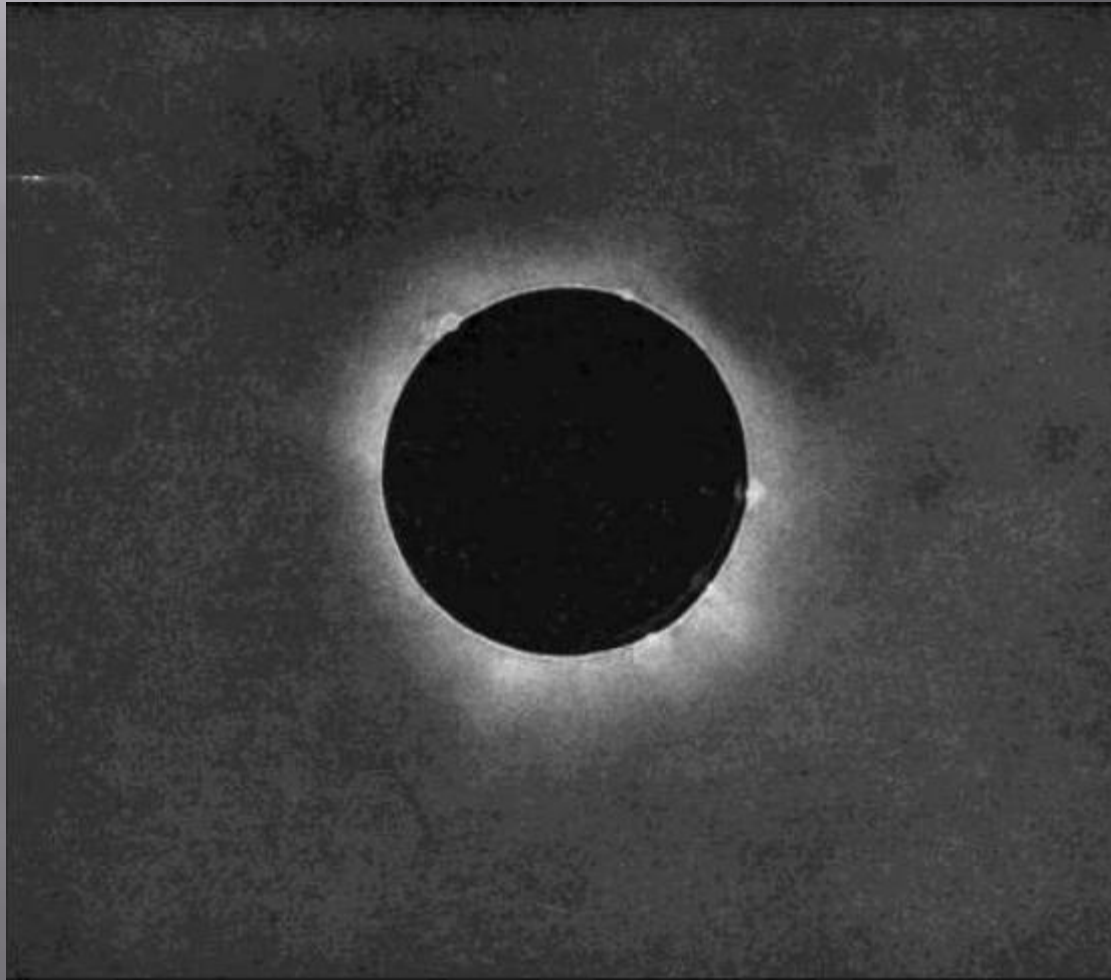


Eclipse of the Sun

Daguerreotype by M Berkowski

1851 - 60mm refractor

24 sec exposure



Daguerreotype of Moon

John Adams Whipple
1852 - Harvard Observatory

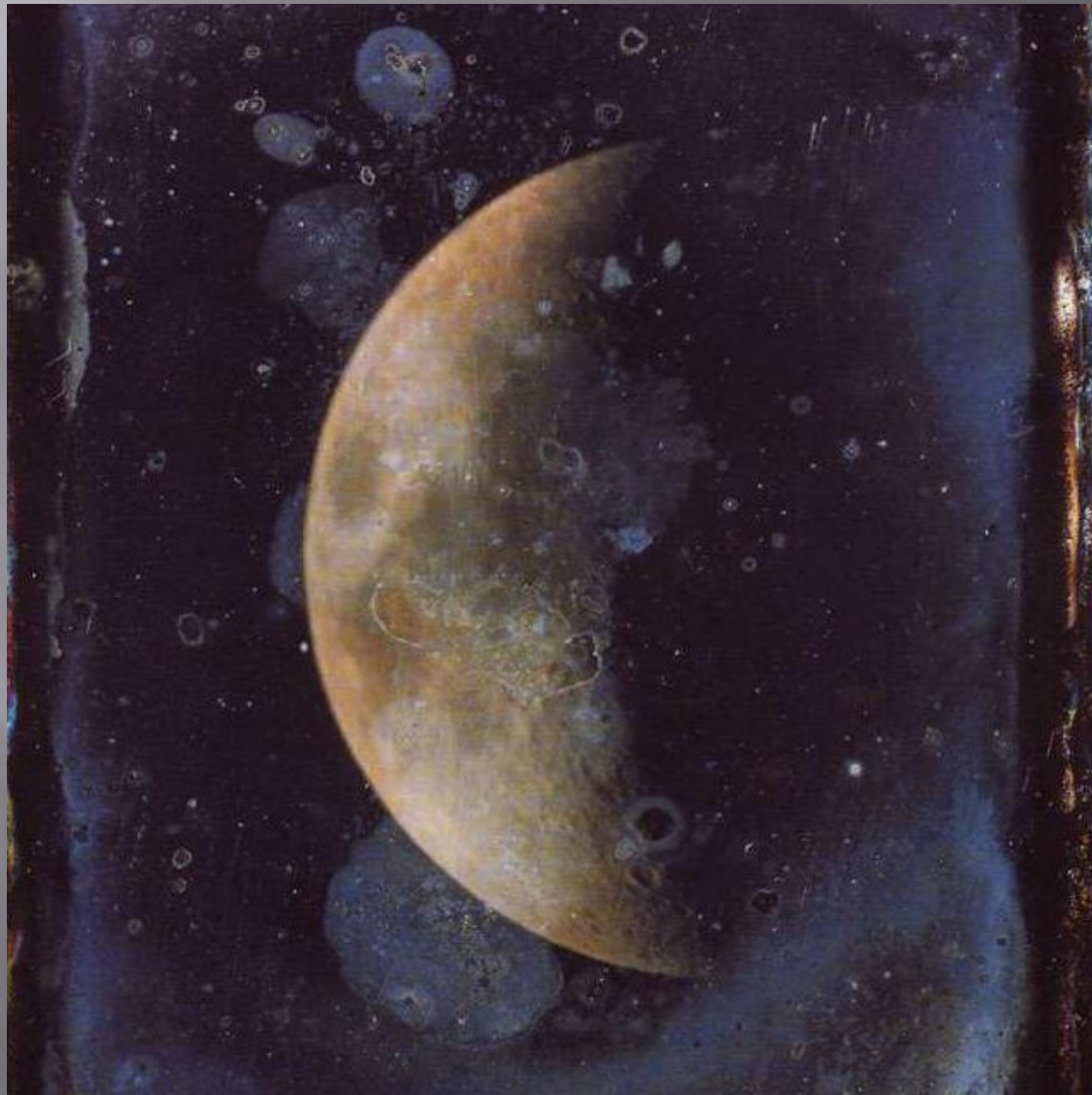
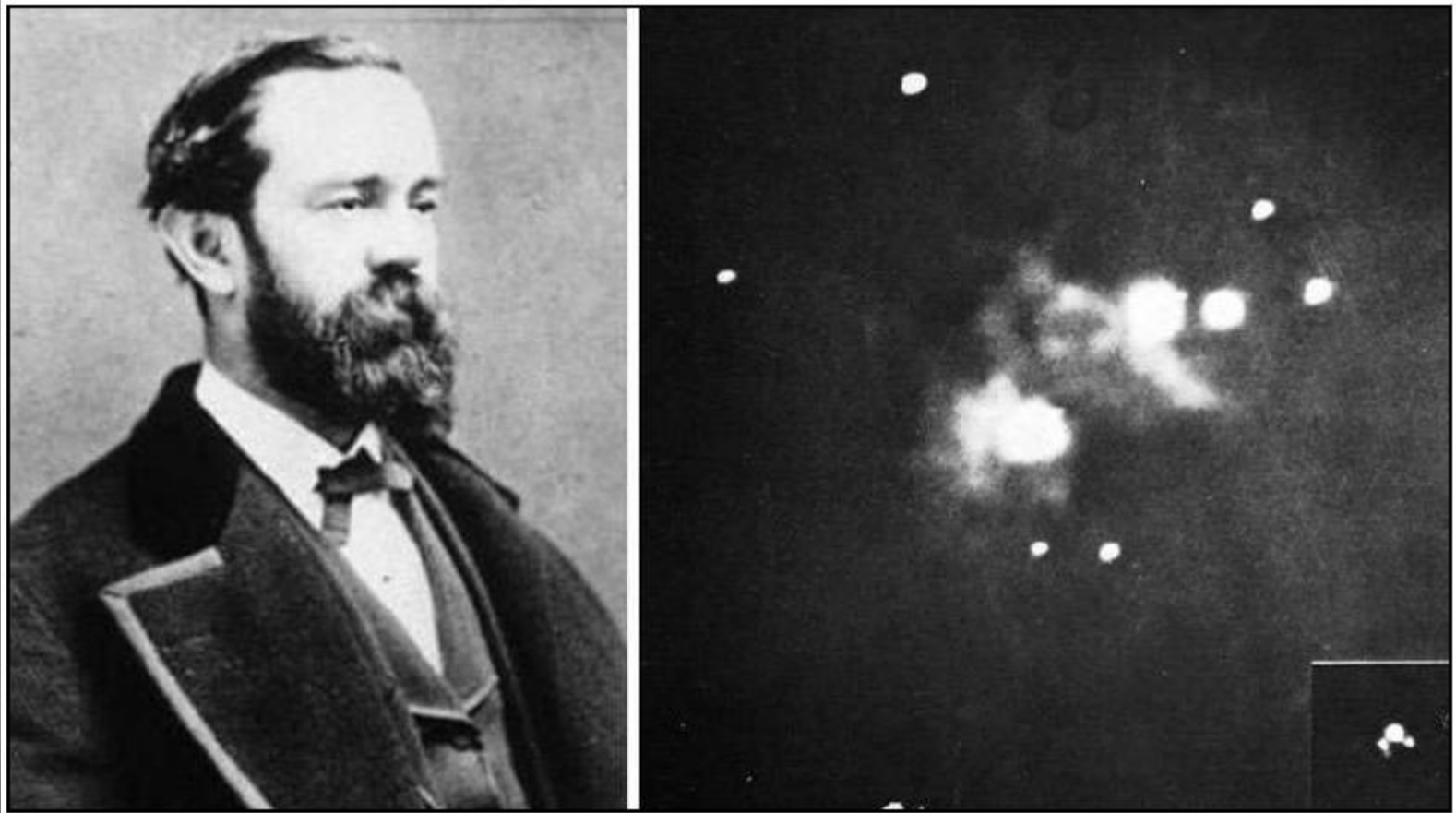


Image of Orion - M42

Henry Draper - 1880



Great Nebula in Orion M42

Andrew A. Common
1883 - Harvard Observatory
91 cm reflector 60min exposure



Saturn

Henry Brothers
1886 - Paris Observatory



M42

James E. Keeler - 1898
Crossley reflector 91cm f/5.7 40 min



M81

G. W. Ritchey- 1910

1.52M reflector - Mt Wilson reflector - 3 ½ hr.



M81

G. W. Ritchey- 1917

1.52M reflector Mt Wilson reflector - 3hr.



Equipment

- ▣ Telescope Optical Assembly
 - Refractor
 - Reflector
- ▣ Mount
 - Alt- Azimuth
 - Equatorial
- ▣ Imager
 - Film
 - Digital
 - ▣ Digital SLR
 - ▣ Dedicated CCD astrophotography camera
- ▣ Computer for image acquisition, guiding control, and image processing

Optical Tube Assembly

▣ Refractor

- Up to about 8" practical for amateurs
- High Contrast
- Must be color corrected for wide fields
- Expensive

▣ Reflector

- Virtually all professional telescopes are reflectors
- Up to 30" or more for amateurs
- Focal ratios from $f/2$ to $f/10$ common
- Color correction not much of a problem
- Physically short for focal length – easier to mount
- Edge correction needed for wide fields

Reflector vs Refractor



9.25" f/10 Apanatic Schmidt
Cassagrain Reflector



130mm f/6.3 Triplet Refractor

Mounts

- ▣ The Astrophotographic Mount is the most critical part of the system
- ▣ Nearly all astrophoto amateur mounts are Equatorial
- ▣ Equatorial mounts have one axis aligned with the axis of the Earth
- ▣ Precision Electronic “Clockwork” drive keeps the target object centered in field
- ▣ Photographs longer than 30” require precision guiding to within 5 arc seconds or better
 - $1/259,000$ of a complete circle
 - Guiding by means of a closed loop digital control system using a second imager and computer.

Film vs Digital

- ▣ Film was the first imaging medium
 - Special films required to overcome reciprocity failure and to increase sensitivity
 - Exposures up to several hours necessary
- ▣ Digital Imaging
 - CCD invented in 1969
 - Large telescopes now use arrays of CCD equivalent to 100 million pixels
 - Sensitivity equal to or better than film
 - No reciprocity failure
 - Exposures can be shortened and images combined in computer to give equivalent of very long exposures

Digital Cameras

- ▣ Recent DSLRs very useful for Astrophotography
 - Canon and Nikon APS sized sensors most common
 - Use ISO 3200+
- ▣ Specialized CCD astro-cameras are available
 - Built-in LCD shutter
 - Very low noise with cooling 40deg C below ambient
 - 6 to 12MP relatively affordable
- ▣ High speed CCDs (15fps) for planetary
 - Avoids problems with atmospheric turbulence

Typical Setup



Astrophotography System



6MP CCD Camera

Steps – Acquiring image

- ▣ Acquiring the Object
 - Plan to have target visible for 2-3 hours overhead
 - Clear night, good seeing, no clouds, no moon
 - Find target and lock image in place with guiding software
 - Focus is critical
- ▣ Capturing the Image
 - Capture main image
 - ▣ 20 min to several hours total
 - ▣ Example: M42 – 36 4minute exposures: 144 minutes total
 - Capture darks: 10 to 15 4 minute black exposures at same temp
 - Capture Flats: Several short images of a uniform white field

Processing

- ▣ The primary objective of processing is to increase the signal to noise ratio
- ▣ Image noise tends to be random
- ▣ Object image increases linearly with exposure
 - Assumes no reciprocity failure
- ▣ Noise increases with the square root of exposure
- ▣ Thus the more quality exposures, the greater the S/N – lower noise

Detailed Processing

- ▣ Programs such as Images Plus, Nebulosity, Registrex
- ▣ Images are taken over an extended time
 - Even with guiding images can shift slightly
 - All images need to be brought into registration
 - ▣ X-Y shift
 - ▣ Scale
 - ▣ Rotation
- ▣ Registered images are combined by “adding”
 - Dramatically increases S/N
- ▣ Final combined images are “stretched” to enhance contrast – specialized “curves” routines
- ▣ Additional work in PS to correct color and local contrast/brightness
- ▣ Multiple images can be combined similar to HRD

Example – M51

D300 - 22 images 183 sec ea (67 minutes total) - AP 130mm F/8 (4/05/2008)



Single image



22 images combined/processed

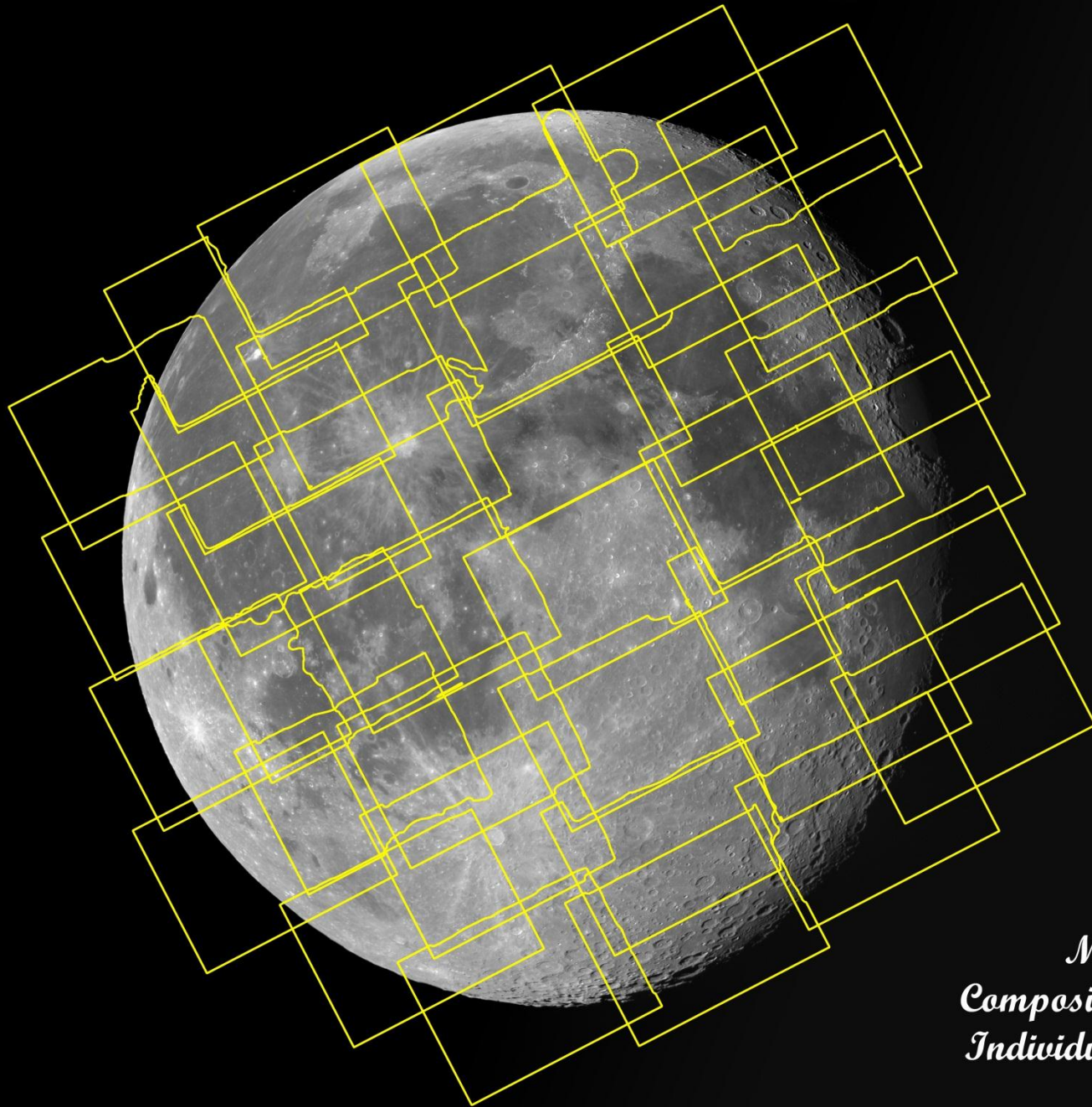
M31 2007-11-07

Single 60sec Image

*181 60 sec Images
Aligned and combined*



Moon
Mosaic 2007-09-28



*Moon
Composite Showing
Individual images*



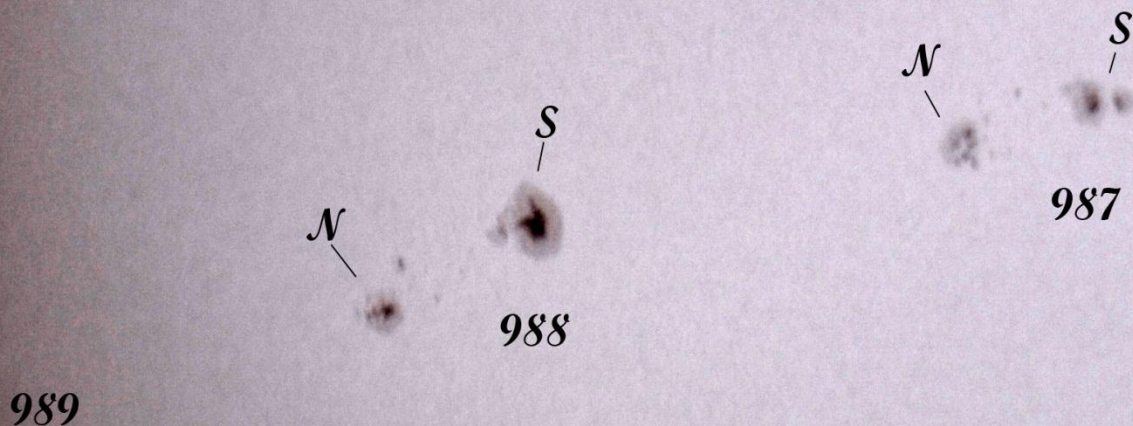
Moon
Craters Clavius & Longomontanus
2007-10-07
Albert F Peter

Lunar Eclipse

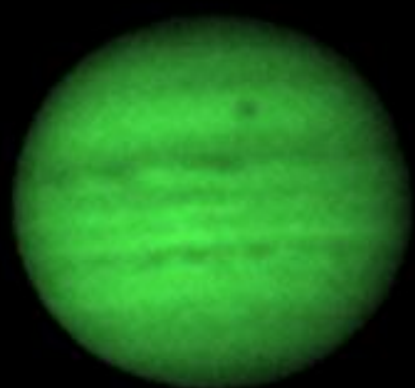


Lunar Eclipse 2008-02-20
Astro-Physics 130mm Starfire ED5 f/8
Cincinnati, Ohio
© Albert F Peter 2008

*These sunspots are part of Cycle 23 that began in 2002,
as shown by their polarity. The new cycle has begun with a
few small spots of reversed polarity (not shown). Cycle 24
will peak in 2012 or 2013.*



Sunspots
#987, 988 & 989
2008-03-26



Jupiter
2007-07-31



Saturn
2008-02-23



M13
Hercules Globular Cluster
2008-08-31



M33

The Triangulum Galaxy

2008-09-01

Albert F Peter



M31 The Andromeda Galaxy

11-01-07

Albert F Peter



M16 The Eagle Nebula
2008-07-01
Albert F Peter



M57 The Ring Nebula
8-10-07



M42 The Great Nebula in Orion

11-17-07

Albert F Peter



M42
2008-11-26
Albert F Peter



M20 - The trifold Nebula
2007-09-12



M8 Lagoon
2008-08-02



M27 Dumbbell Nebula
8-11-07



Adhafera

Algieba

Rasalas

Saturn

Regulus

Alterf

Mars

Iridium Flare



*Moon, Mars Saturn, Regulus
& Iridium 45 Flare
2008-06-08, 23:03
Nikon D300 24mm
Albert F Peter*



10-28



10-30



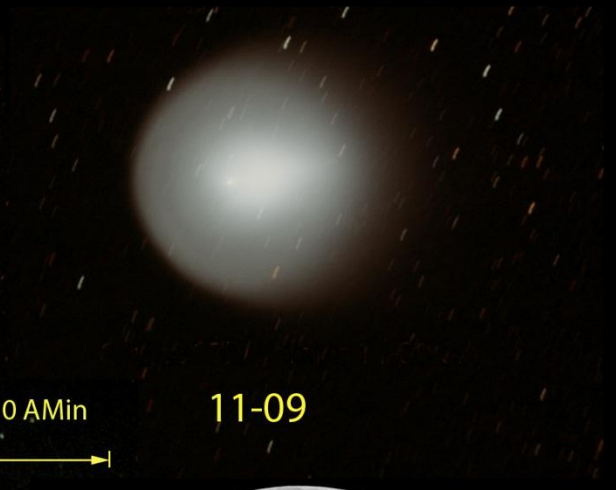
11-02



11-04



11-07

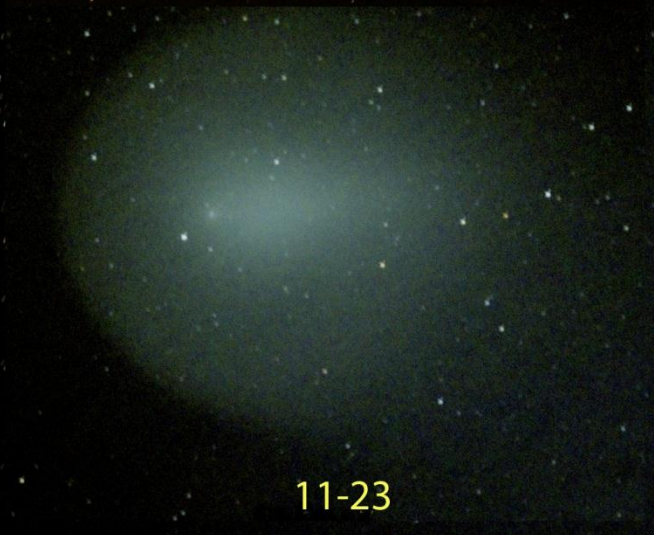


11-09

10 AMin
↔



11-17



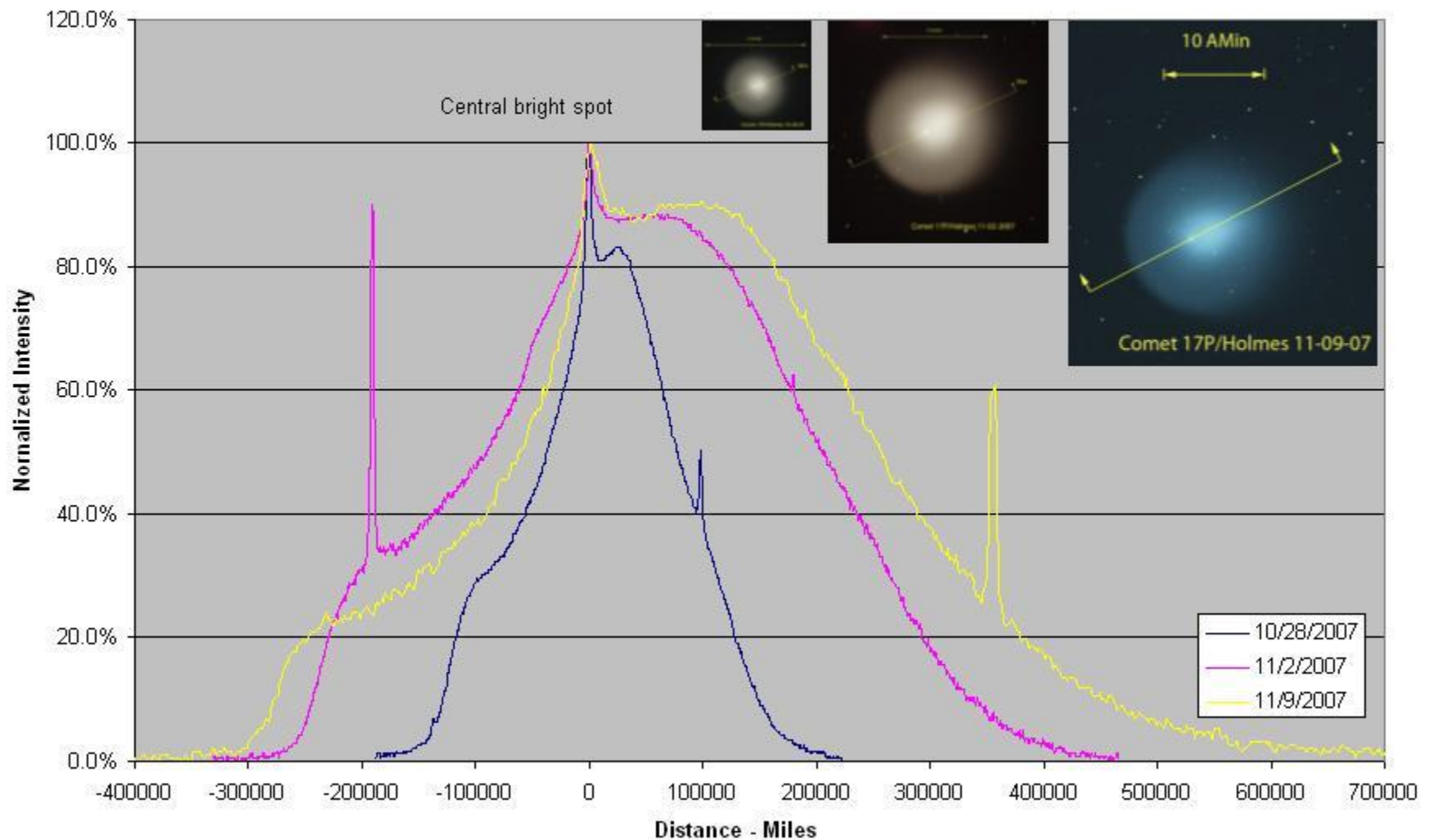
11-23



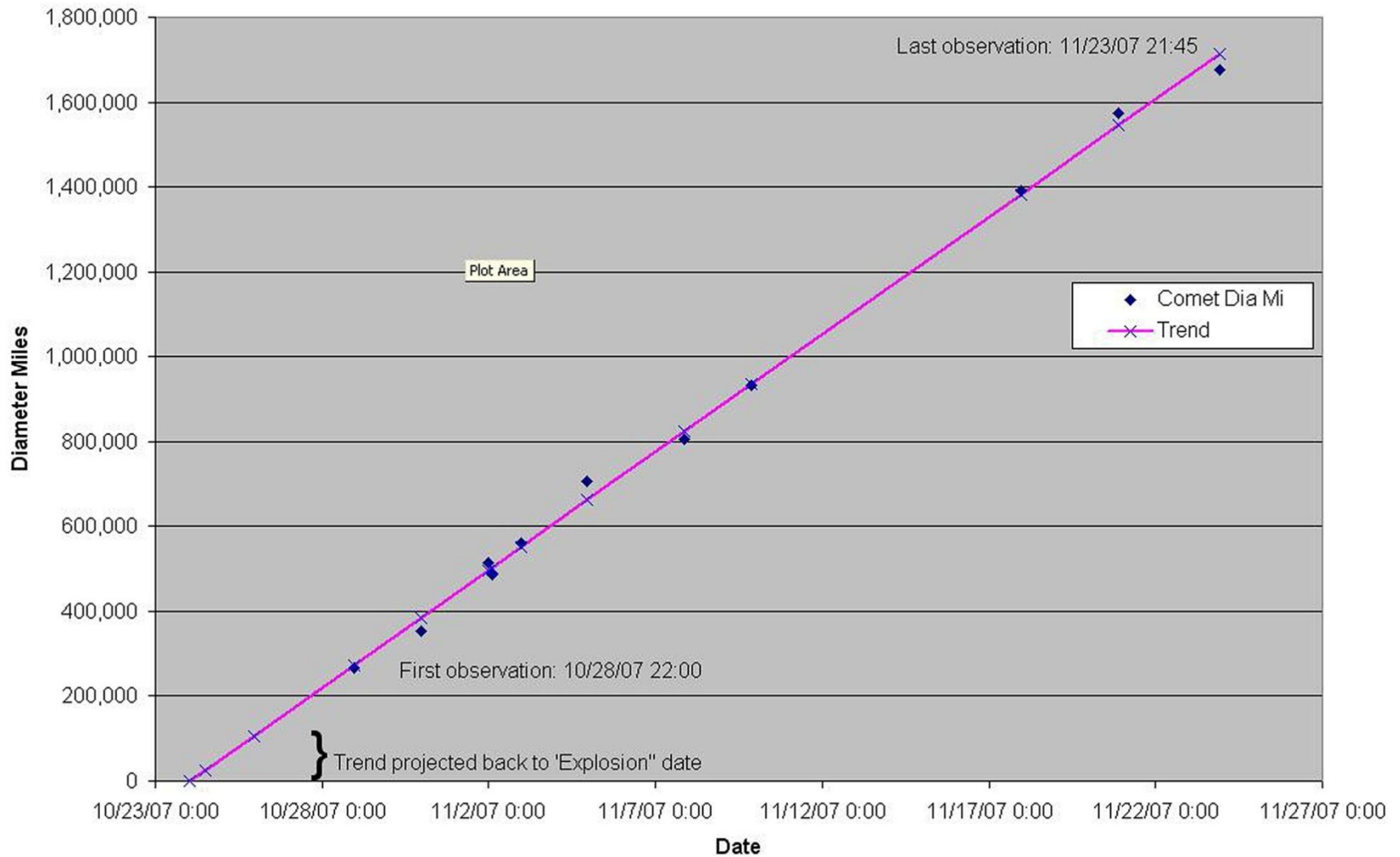
Comet 17P/Holmes 10-28-07 to 11-23-07

Moon 11-23 (to scale)

Normalized Intensity Comet 17P Holmes 11-09-07



Comet 17P/Holmes Coma Diameter



Hubble Image

“Light Echo” Dust around super giant star
V838 in Monoceros



Hubble Image

Sombrero Galaxy • M104



Hubble
Heritage

