LEBANON CAMERA CLUB

Astrophotography and the Great Eclipse of 2017

5/2/2017

Astrophotography and the 2017 Eclipse

Astrophotography

Note: Images with a yellow border were taken by me. The others are from the Internet.

- Photographing astronomical objects
  - Solar system → Sun, Moon, planets, comets, meteors
  - Deep space → stars, galaxies, nebulae (planetary & diffuse)










Astrophotography and the 2017 Eclipse

Astrophotography & Me

Note: The 1910 appearance caused panic because the Earth went through the tail → some people thought it was poisonous

- Halley's Comet
  - Appears once every 76 years → last time in 1986
    - 1910: spectacular everywhere → tail was huge

tion will be restored for another month.

COMING END OF WORLD

Halley's Comet May Snuff Out Life on the Earth

Berkeley, Cal., Feb. 9.—"If the astronomers are right in their estimations of the amount of cyanogen gas in the tail of Halley's comet, and if that body's vapors do envelop the earth, we may have a chance to feel the sensations of the bugs and insects which are killed by the use of this deadly gas as an exterminator."

Astrophotography and the 2017 Eclipse

Astrophotography & Me

Note: Aruba is at 12º N latitude, Lebanon is at 40º N latitude → Halley's Comet was 28º higher in the sky

- Halley's Comet
  - Appears once every 76 years → last time in 1986
    - 1910: spectacular everywhere
    - 1986: better in southern hemisphere, but nothing like 1910
    - I took a trip to Aruba to see and photograph it

Astrophotography and the 2017 Eclipse

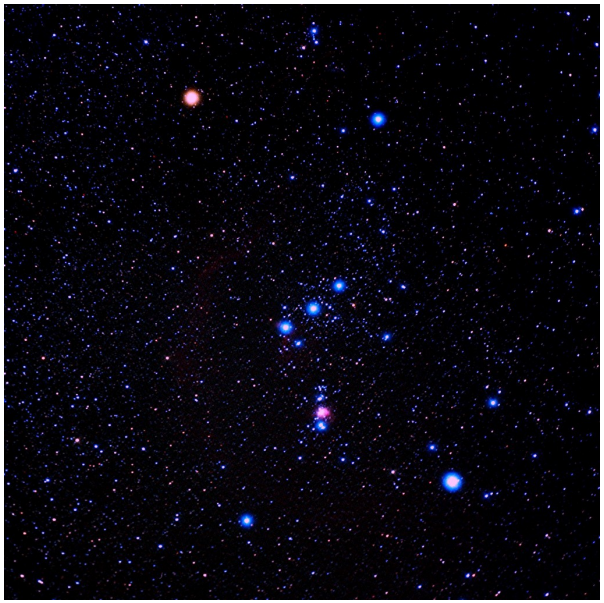
Astrophotography & Me

- Halley's Comet
  - My first camera purchase → Minolta X-370 & 85 mm lens
    - Also took along a borrowed 100 mm lens
    - Problem: need 2 minute exposure → stars would not be points!

Astrophotography and the 2017 Eclipse

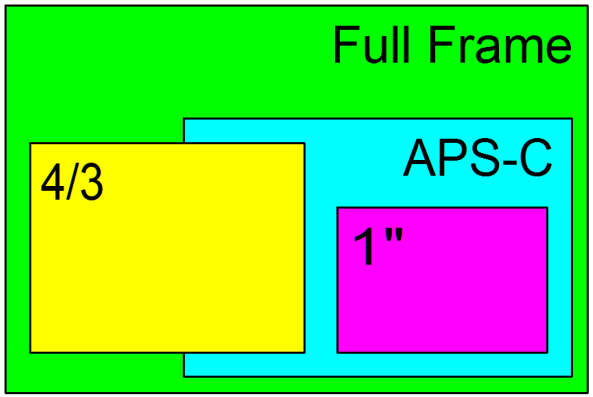
Astrophotography

- Lens
  - You can do astrophography with an ordinary camera lens
    - Wide angle → landscape with stars, star trails, Milky Way
    - Normal → Milky Way
    - Telephoto → constellations, star fields, comets
    - Super-telephoto → Sun, Moon, open star clusters, diffuse nebula



Astrophotography and the 2017 Eclipse

Astrophotography



- Lens
  - Required focal length depends on:
    - Size of subject
    - Size of sensor → smaller sensor results in smaller field of view
    - Same # of pixels, smaller area = smaller pixels = less image quality

Andromeda galaxy
1000 mm telescope APS-C sensor

Andromeda galaxy
1000 mm telescope 1” sensor

Astrophotography and the 2017 Eclipse

Astrophotography

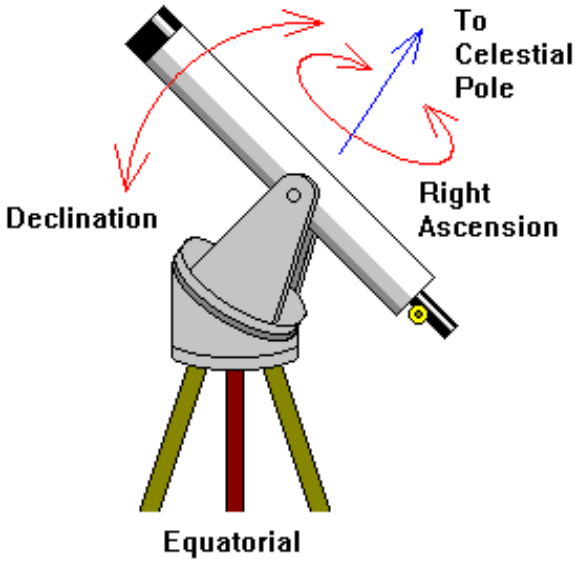
- Tracking celestial motion
  - Long exposures reveal Earth's rotation → star trails
    - Longer focal length → more motion
    - Example: 30 sec exposure, 400 mm lens (same as 2 min, 100 mm lens)

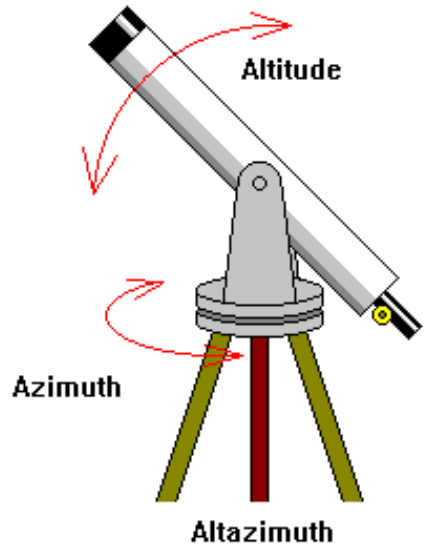
Astrophotography and the 2017 Eclipse

Astrophotography

Note: The “polar axis” points toward the north star, Polaris, which aligns the axis with Earth's axis

- Tracking celestial motion
  - Long exposures reveal Earth's rotation → star trails
    - Longer focal length → more motion
  - Solution: mount that can compensate for Earth's rotation
    - Equatorial mount with drive motor
    - Alt-azimuth mount with computer control





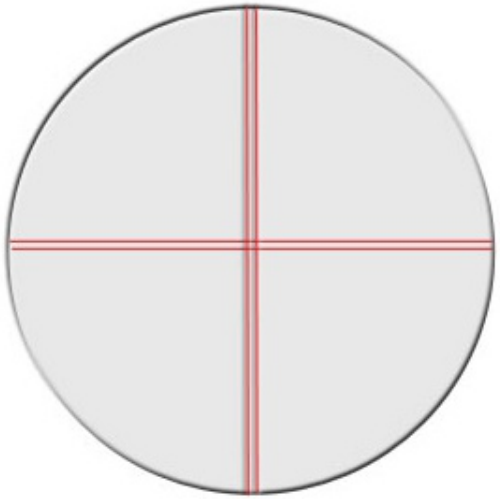
Astrophotography and the 2017 Eclipse

Astrophotography & Me

- Halley's Comet
  - My first camera purchase → Minolta X-370 & 85mm lens
    - Also took along a borrowed 100mm lens
    - Problem: need 2 minute exposure → stars would not be points!
    - Low-tech solution: geared tripod head turned by hand + finder scope

Spiratone geared tripod head

finder scope with illuminated reticle eyepiece



illuminated reticle

Astrophotography and the 2017 Eclipse

Astrophotography & Me

- Halley's Comet
  - Images from Aruba

Halley's Comet March, 1986

Alpha & Beta Centauri and the Southern Cross March, 1986

Astrophotography and the 2017 Eclipse

Astrophotography & Me

- Bitten by the astronomy bug
  - My 1st telescope → Meade 320 + drive motors
    - 80mm aperture, 900mm focal length → f/11
    - Unfortunately, too "slow" for faint objects like nebulae
  - My 2nd telescope → Celestron Short Tube
    - 80mm aperture, 400mm focal length → f/5
    - Used "piggyback" on the Meade 320

Celestron
short tube
80mm f/5

Meade
320
80mm f/11

Astrophotography and the 2017 Eclipse

Astrophotography & Me

Note: A total solar eclipse means the Moon fully blocks the Sun

- 1991 total solar eclipse
  - Visible on the west coast of Mexico
    - I took an eclipse cruise to Mazatlan to try to photograph it
    - Celestron 80mm + 2.5x Barlow (similar to a teleconverter for camera lenses)
    - Unfortunately, clouds rolled in before totality

my Dad watching the clouds

not my photo, but is what I saw before the clouds came

Astrophotography and the 2017 Eclipse

Astrophotography

- A difficult hobby
  - Weather and visibility
    - Clouds are the enemy!
    - Atmospheric refraction ("twinkle") → "seeing" is best in cold weather
    - Need to travel to dark skies (light pollution) or eclipse locations
  - Mostly done at night
    - Can result in sleep deprivation
    - It's easy to damage equipment when you are sleepy in the dark
    - Many astrophotographers now automate their equipment
  - Expensive!
    - Good telescopes cost a lot, and astronomers are never satisfied
    - Top quality photography requires an ultra-stable mount → $$$
    - You need lots of accessories, which are also expensive
    - Lots of down time to fantasize about better equipment

Astrophotography and the 2017 Eclipse

Astrophotography & Me

- After 1991
  - Moon & Sun photography in 2013
    - Assigned subject for May was “Moon”
    - Meade 320 + APS-C sensor camera (Sony A57)
    - Decent results on the Moon, less so on the Sun

Astrophotography and the 2017 Eclipse

Astrophotography

- Viewing the Sun
  - Dangerous!
    - CAN BLIND INSTANTLY THROUGH A TELESCOPE!!
    - CAN BLIND INSTANTLY THROUGH A CAMERA LENS!!
    - Can be viewed safely by the naked eye ONLY at complete totality

Note: Complete totality means **NO** part of the Sun is visible, not even “Baily's beads” which occur when the Sun shines through valleys on the lunar surface

Astrophotography and the 2017 Eclipse

Astrophotography

- Viewing the Sun
  - Dangerous!
    - CAN BLIND INSTANTLY THROUGH A TELESCOPE
    - CAN BLIND INSTANTLY THROUGH A CAMERA LENS
    - Can be viewed safely by the naked eye ONLY at complete totality
    - Sun at sunset is much less intense than at noon, but still a danger
    - DSLR viewfinder may be “safe” at sunset, but not at noon
    - A mirrorless camera viewfinder is safe because it is an LCD
    - Digital sensor may be damaged by concentrated light (overheating)
    - Digital sensor probably okay at totality because hot spots are small

Astrophotography and the 2017 Eclipse

Astrophotography

Note: Mylar solar filters come in visual and photographic (less intense) grades → make sure you have a visual filter for viewing by eye

- Viewing the Sun
  - Filter needed to view Sun at any time other than totality
    - Reduces light by 1/100,000
    - Either a mylar film (better) or aluminized glass (old standard)
    - "Eclipse glasses" are usually mylar, and are effective (if good quality)
    - For telescope (or lens), filter should be in front to prevent heat buildup

mylar solar filter

glass solar filter

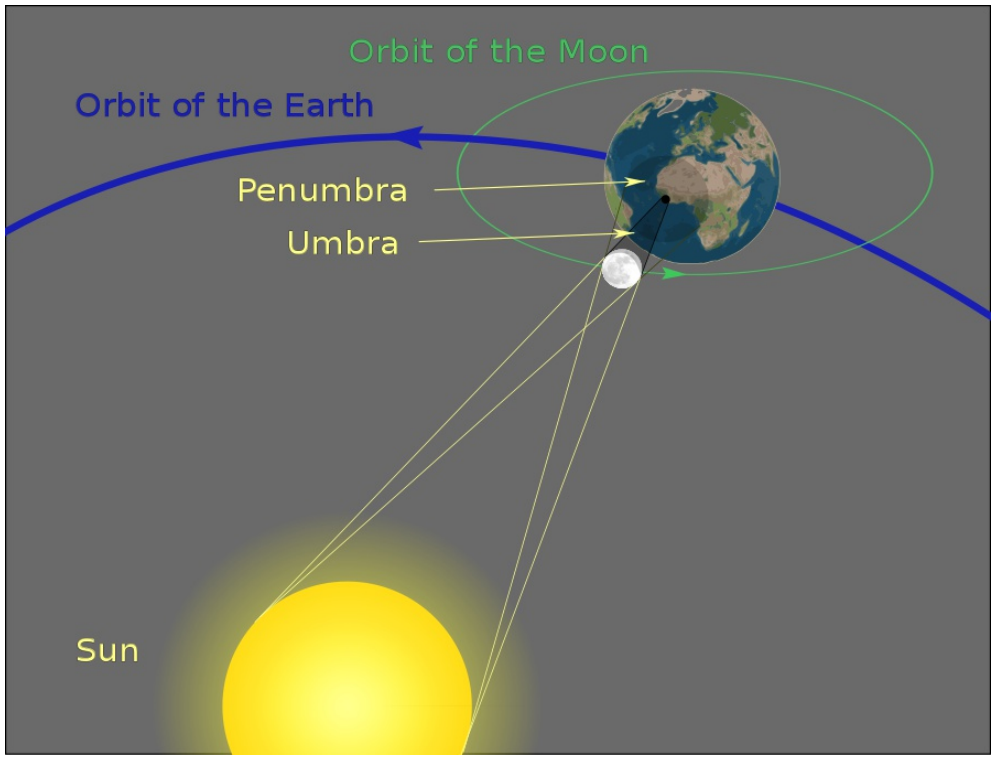
eclipse glasses (mylar)

Astrophotography and the 2017 Eclipse

Great Eclipse of 2017

Date: August 21, 2017

- Total solar eclipse visible in the USA
  - Moon moves between the Sun and the Earth
    - Would happen every month if the Moon's orbit wasn't tilted
    - At least 4 per year, but some are partial or “annular”



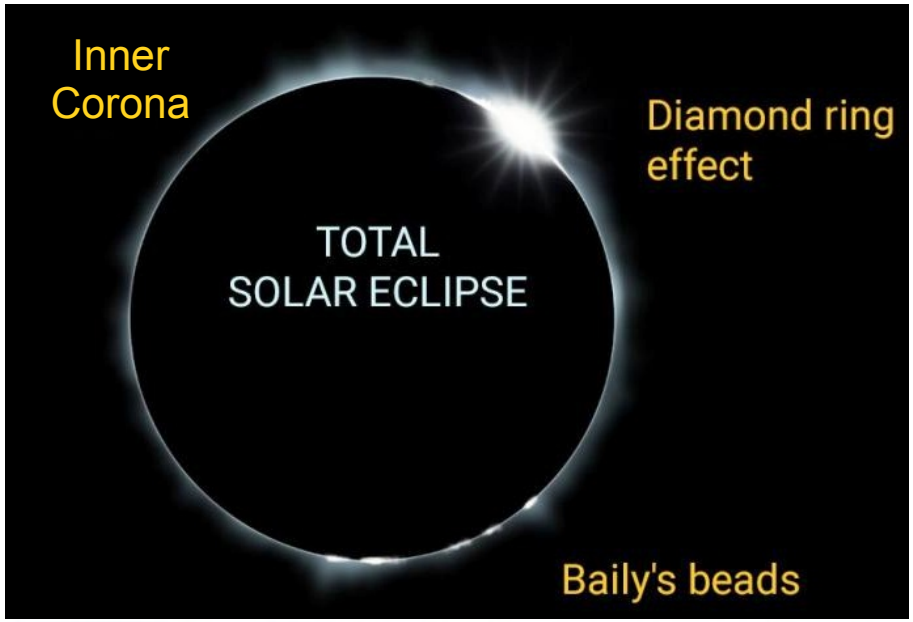
partial eclipse: moon never fully covers the sun

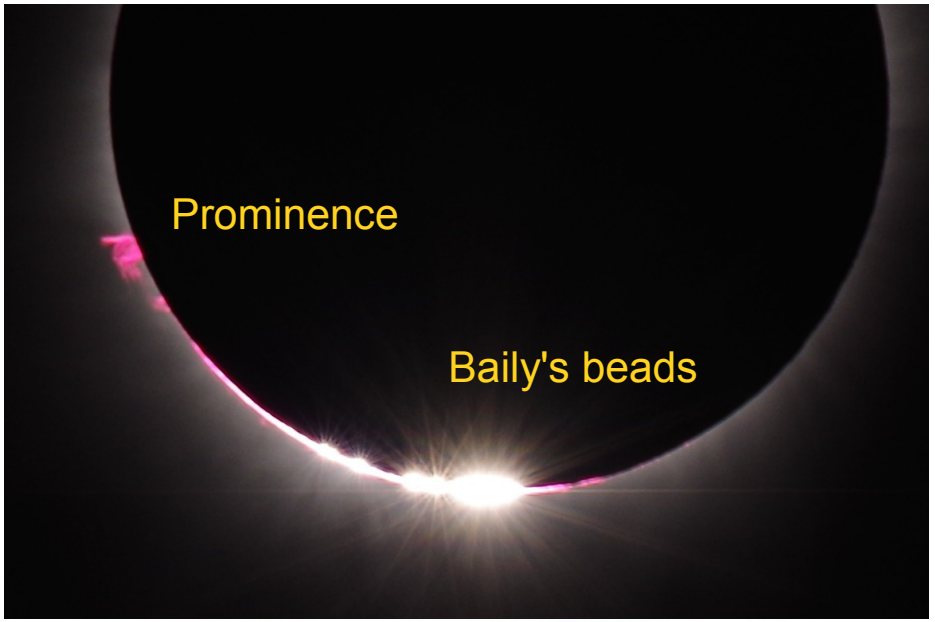
annular eclipse: moon smaller than the solar disk

Astrophotography and the 2017 Eclipse

Great Eclipse of 2017

- Total solar eclipse visible in the USA
  - Features of totality
    - Diamond ring effect → last bit of Sun visible before totality
    - Baily's beads → sun reaching Earth through lunar valleys
    - Prominences → loops of "cool" plasma extending beyond the Sun
    - Corona → aura of "hot" plasma extending well beyond the Sun





Astrophotography and the 2017 Eclipse

Great Eclipse of 2017

- Total solar eclipse visible in the USA
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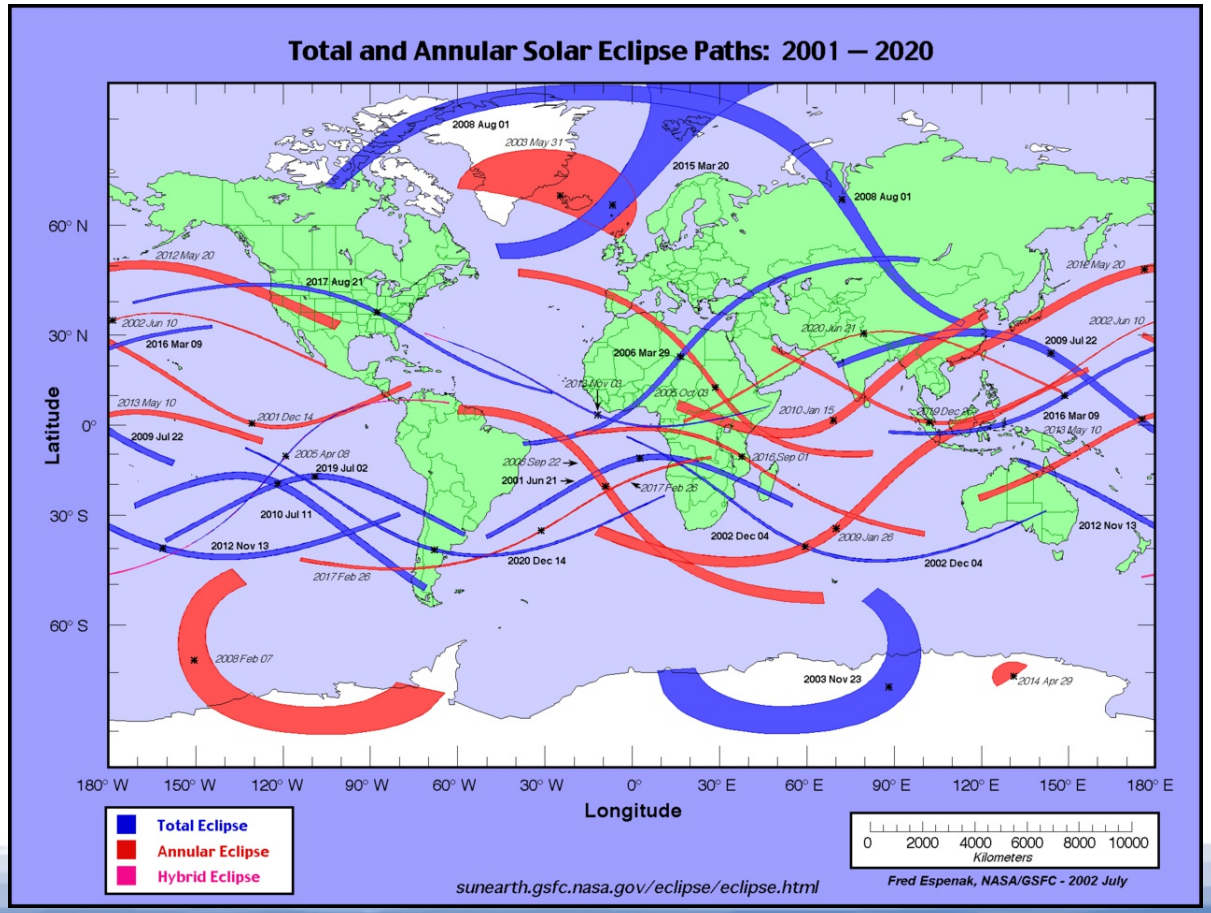
Astrophotography and the 2017 Eclipse

Great Eclipse of 2017

- Total solar eclipse visible in the USA
  - Relatively rare event for a specific location on Earth
    - Last one visible in the USA was in 1979, next one in 2024

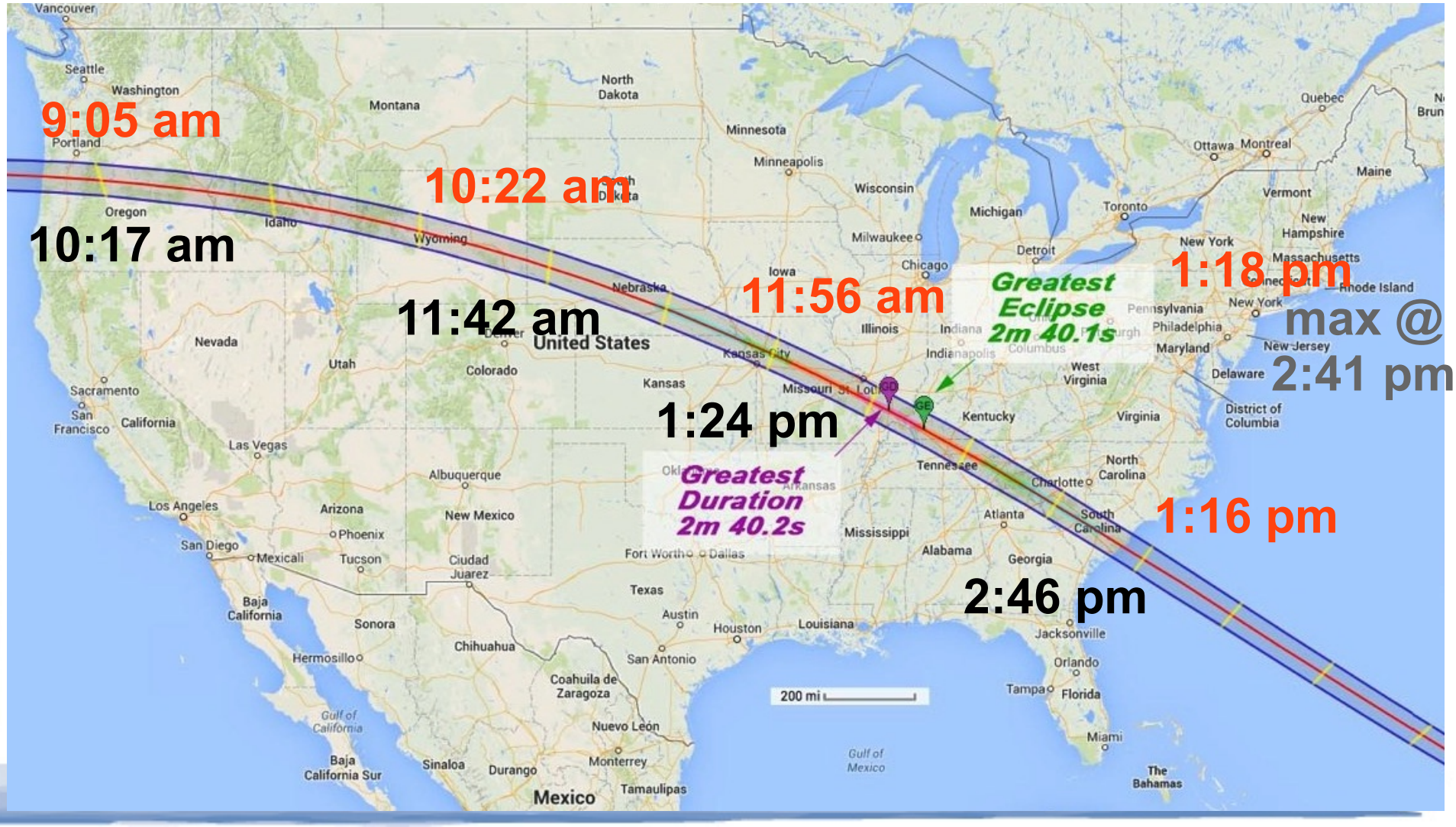


Astrophotography and the 2017 Eclipse

Great Eclipse of 2017

Note: Times off the track are for Lebanon, PA (partial eclipse only)

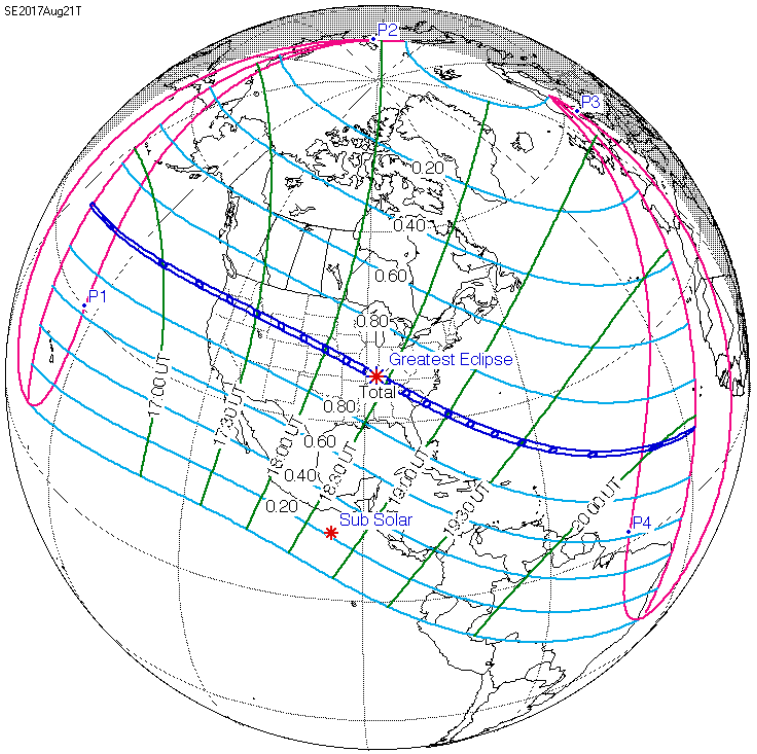
- Track (local times for start of **partial** and **total** eclipse)



Astrophotography and the 2017 Eclipse

Great Eclipse of 2017

- Not total in Pennsylvania
  - Path of totality is 71 miles wide
    - Duration is longest along the center line
    - Path of partial eclipse is thousands of miles wide



Astrophotography and the 2017 Eclipse

Great Eclipse of 2017

Note: It does not get completely dark during a total eclipse, because sky illumination still exists away from the totality track

- Not total in Pennsylvania
  - 76% of the Sun will be covered in Lebanon
    - Should be some darkening, but not as impressive as a total eclipse
    - No diamond ring effect, Baily's beads, prominences, or corona :-(
  - Have to get creative!

approximate coverage in Lebanon, PA

projection through leaves

pinhole projection

Astrophotography and the 2017 Eclipse

Great Eclipse of 2017

Note: Technically, the greatest duration will be in southern Illinois (by a tiny amount) but the greatest magnitude is near Hopkinsville and the duration is almost the same

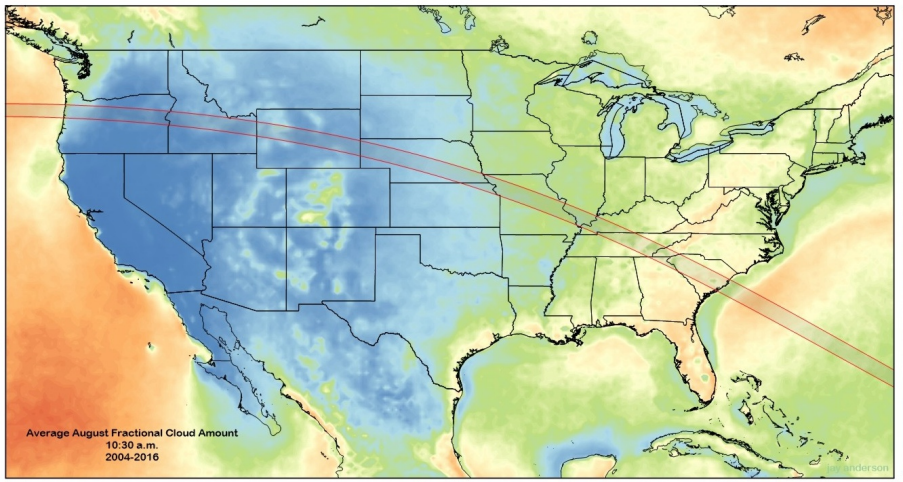
- Duration
  - Total
    - Maximum: 2 minutes 40 seconds → near Hopkinsville, Kentucky
    - Time (at maximum): 1:24:38 pm – 1:27:21 pm (central daylight time)
  - Partial + total
    - Maximum (Hopkinsville, KY): 2 hours 54 minutes 30 seconds
    - Max time (Hopkinsville, KY): 11:56:31 am – 2:51:41 pm (cdt)
    - Lebanon: 2 hours 40 minutes 58 seconds
    - Lebanon time: 1:18:17 pm – 3:59:15 pm (eastern daylight time)

Astrophotography and the 2017 Eclipse

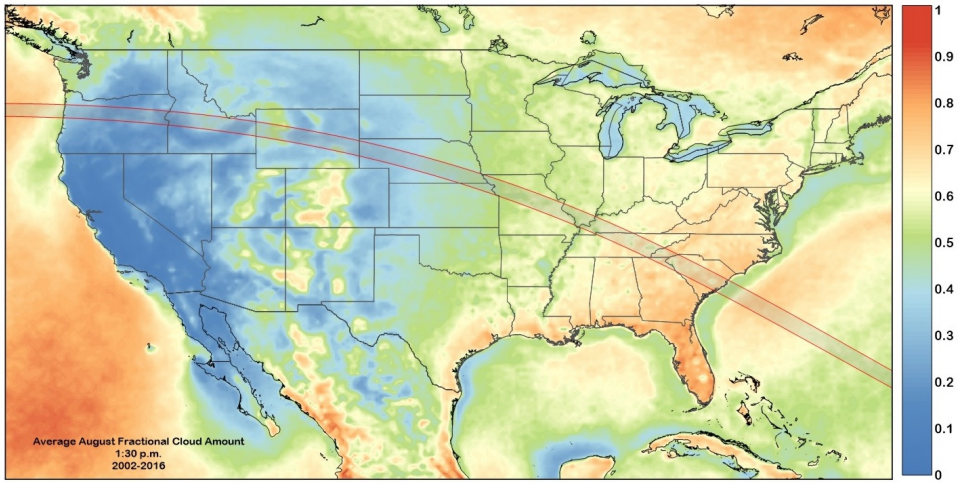
Great Eclipse of 2017

Note: Totality is less than 3 minutes → a big cloud could take 1 or 2 minutes to pass by

- Optimal viewing
  - Maximizing visibility
    - Clouds are the enemy! → max duration useless if you can't see it
    - On average, western U.S. has fewer clouds than eastern U.S.
    - Best states: Oregon, Idaho, Wyoming, western Nebraska



average US cloud cover @ 10:30 am
blue is fewest clouds, red is most clouds



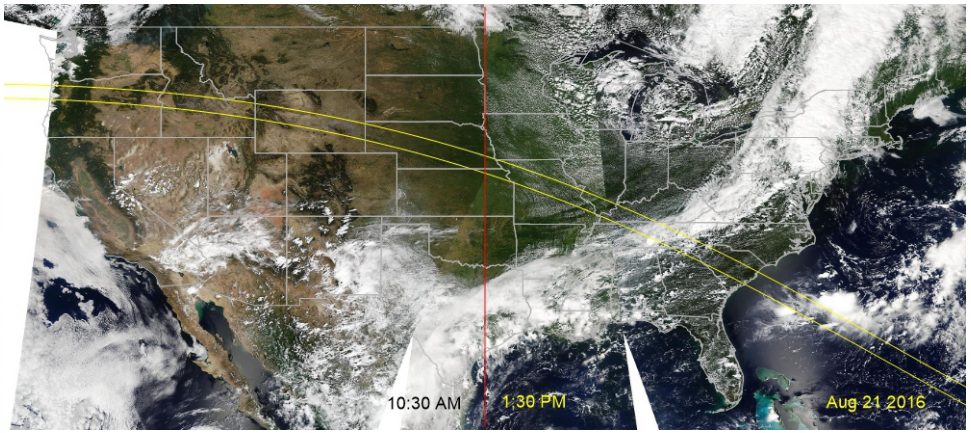
average US cloud cover @ 1:30 pm
blue is fewest clouds, red is most clouds

Astrophotography and the 2017 Eclipse

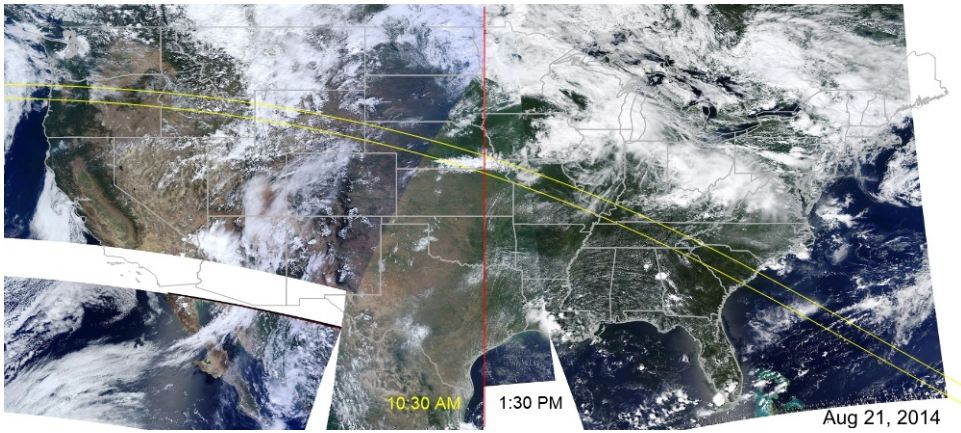
Great Eclipse of 2017

Note: This time I'm waiting for a reliable weather report to decide where to go → could be anywhere from Wyoming to South Carolina

- Optimal viewing
  - Maximizing visibility
    - Clouds are the enemy! → max duration useless if you can't see it
    - On average, western U.S. has fewer clouds than eastern U.S.
    - Best states: Oregon, Idaho, Wyoming, western Nebraska
    - Problem: any location could be cloudy → flexibility is key



cloud cover for August 21, 2016
10:30 am in the west – 1:30 pm in the east



cloud cover for August 21, 2014
10:30 am in the west – 1:30 pm in the east

Astrophotography and the 2017 Eclipse

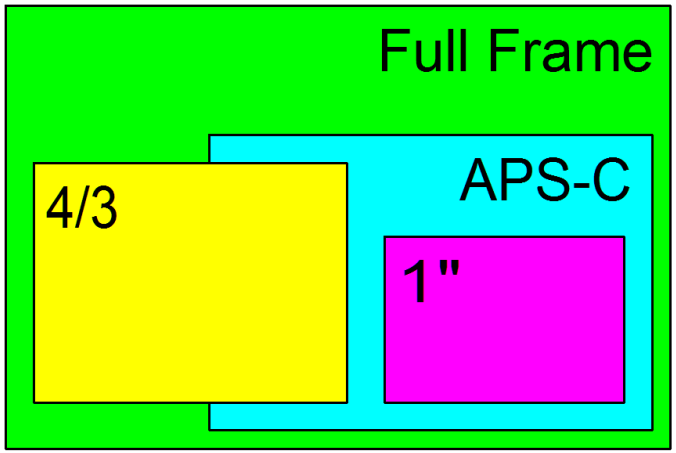
Great Eclipse of 2017

- Optimal viewing
  - Maximizing scenic potential
    - Eclipse landscape better with lower sun → this time the sun is high
    - Sun angles: Oregon = 40º, Kentucky = 64º, South Carolina = 69º

Ansel Adams "Black Sun" photograph – not a real eclipse, the black sun was a result of the extreme overexposure of the sun on film. However, it is an example of a possible landscape photo when a solar eclipse is near the horizon.

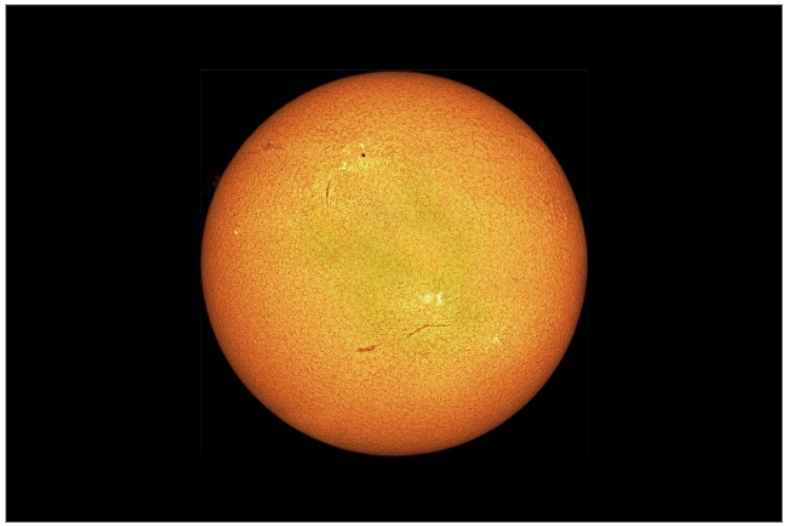
Astrophotography and the 2017 Eclipse

Great Eclipse of 2017



- Focal length
  - Sun closeup
    - ~75% of the vertical frame
    - Full frame = 1955 mm
    - APS-C = 1276 mm (1000 mm = ~59% of the vertical frame)
    - 4/3 = 1064 mm
    - 1” = 720 mm (600 mm = ~63% of the vertical frame)

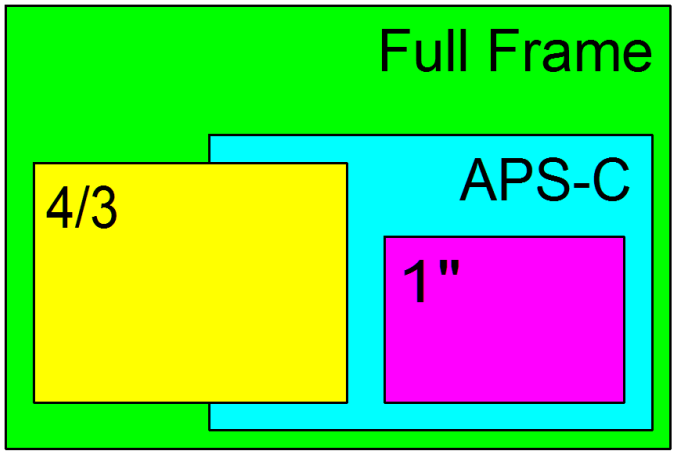
Sun closeup: diamond ring, Baily's beads, prominences, inner corona



field of view for a 720 mm telescope using a 1” sensor

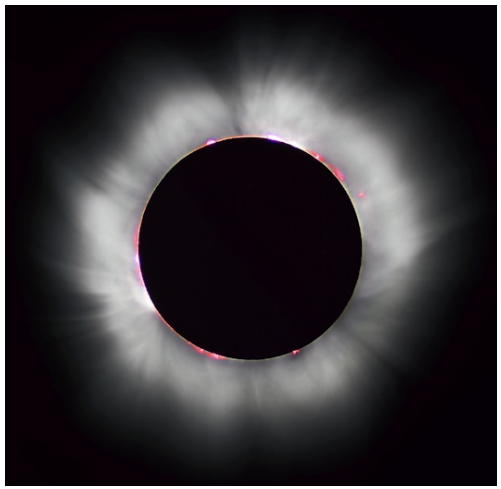
Astrophotography and the 2017 Eclipse

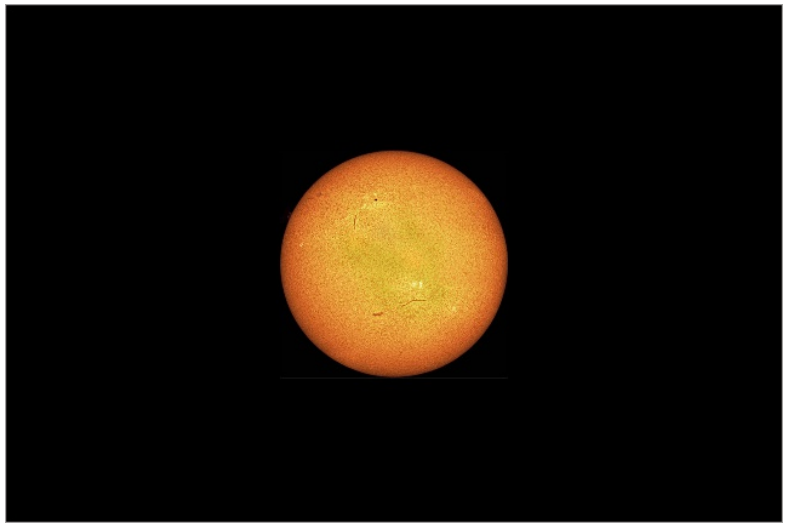
Great Eclipse of 2017



- Focal length
  - Sun + middle corona
    - ~45% of the vertical frame for the Sun
    - Full frame = 1149 mm
    - APS-C = 750 mm (500 mm = ~30% of the vertical frame for the Sun)
    - 4/3 = 625 mm
    - 1” = 423 mm (300 mm = ~32% of the vertical frame for the Sun)

middle corona

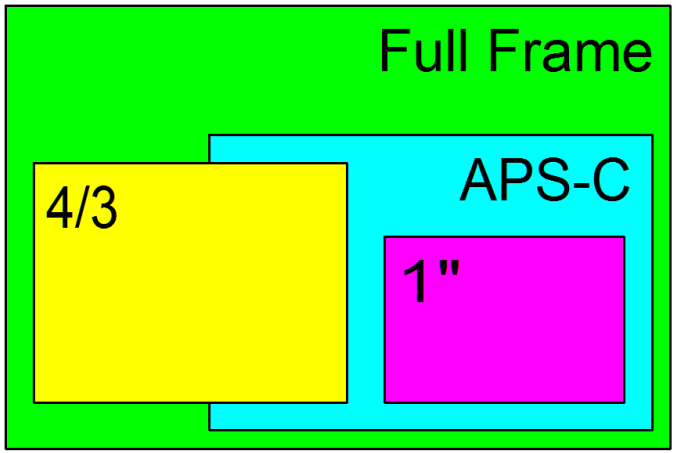




field of view for a 750 mm telescope using an APS-C sensor

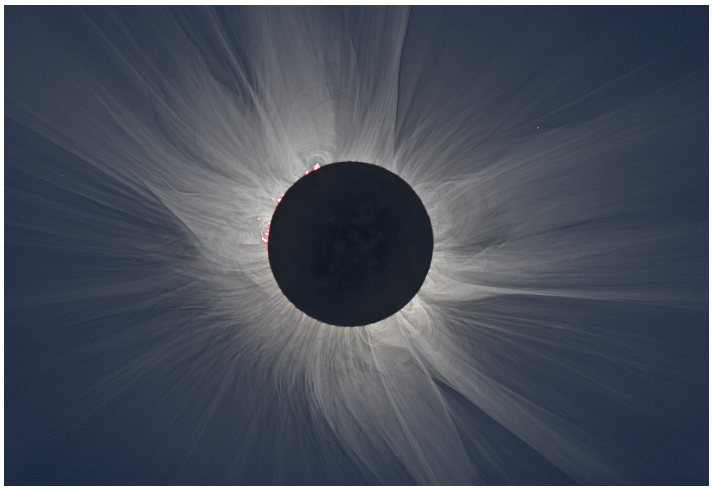
Astrophotography and the 2017 Eclipse

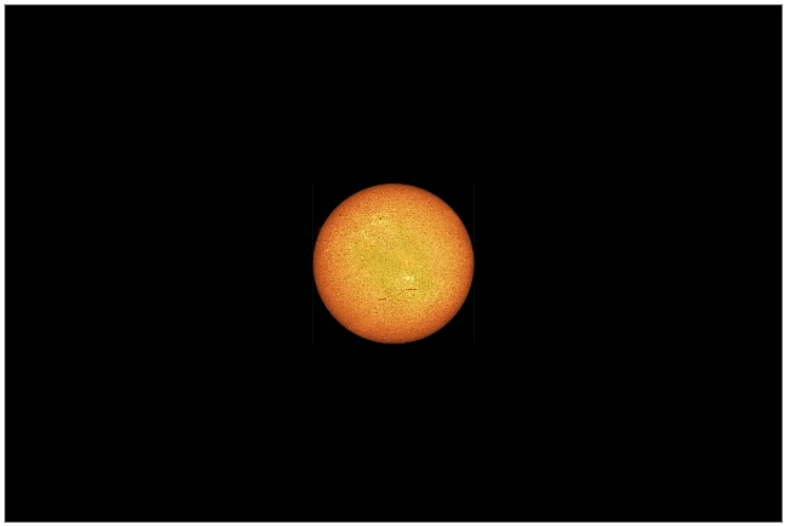
Great Eclipse of 2017



- Focal length
  - Sun + outer corona
    - ~32% of the vertical frame for the Sun
    - Full frame = 815 mm
    - APS-C = 532 mm (400 mm = ~24% of the vertical frame for the Sun)
    - 4/3 = 443 mm
    - 1” = 300 mm

outer corona





field of view for a 300 mm telescope using a 1” sensor

Astrophotography and the 2017 Eclipse

Great Eclipse of 2017

- Exposure at totality (no filter)

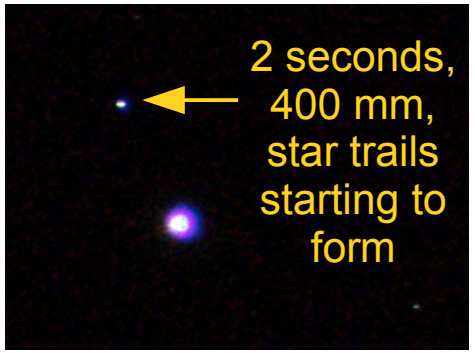
1. Choose ISO
2. Move right to f-number of lens
3. Move down to phenomenon row for shutter speed

ISO	F/Stop					
100	2.8	4	5.6	8	11	16
200	4	5.6	8	11	16	22
400	5.6	8	11	16	22	32
800	8	11	16	22	32	45
1600	11	16	22	32	45	64
Phenomenon	**Shutter Speed**					
Bailey's Beads	na	1/8000	1/4000	1/2000	1/1000	1/500
Diamond Ring	1/500	1/250	1/125	1/60	1/30	1/15
Prominences	1/8000	1/4000	1/2000	1/1000	1/500	1/250
Inner Corona	1/125	1/60	1/30	1/15	1/8	1/4
Middle Corona	1/30	1/15	1/8	1/4	1/2	1
Outer Corona	1/2	1	2	4	8	16

Astrophotography and the 2017 Eclipse

Great Eclipse of 2017

Note: DSLR mirror will cause vibrations → use mirror lockup if available



- Exposure @ partial eclipse (with filter!)
  - Same as normal sun photography
  - Depends on filter
    - Determine proper exposure prior to eclipse
    - Example: glass filter & f/11 scope (tracking) → 1/125 @ ISO 100
- Shutter speed
  - Not tracking → must be fast enough to "freeze" motion
    - "600 Rule" → 600 / focal length = minimum shutter speed
    - Example: 400 mm lens → 600 / 400 = 1.5 seconds max open time
    - Just an estimate → might be better to use 2x the speed for safety
- ISO
  - Use ISO needed for desired shutter speed at lens aperture
    - For telescope, aperture is fixed – for lens, aperture can be adjusted

Astrophotography and the 2017 Eclipse

Astrophotography

- Long focal length camera lenses
  - Super-telephoto
    - Primes are better than zooms
    - Fast primes are very expensive and heavy
    - Slower versions are more reasonable and better for astrophotography
    - Don't use diaphragm in lens → use step-down ring on filter threads to reduce aperture (aberrations are lower for center of lens)

Astrophotography and the 2017 Eclipse

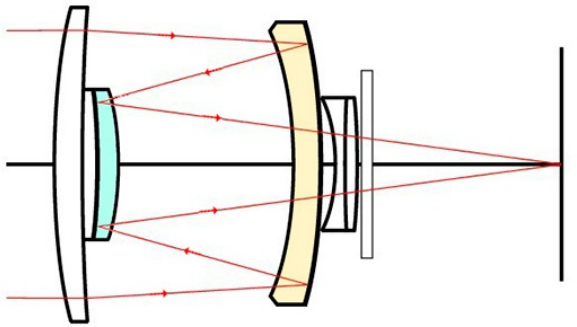
Astrophotography

- Long focal length camera lenses
  - Telephoto + teleconverter
    - 1.4x and 2x focal length multiplier
    - 1.4x adds 1 stop to lens f-number, 2x adds 2 stops to lens f-number
    - Magnifies central area of image → some loss of image quality

Astrophotography and the 2017 Eclipse

Astrophotography

- Long focal length camera lenses
  - Mirror lens
    - Mirrors enable "folded" light path, so lens is much shorter (and lighter)
    - Fixed aperture → no ability to change basic lens f-number
    - Inexpensive ($100-$300), but quality varies
    - Focal length for new lenses: 300 mm, 500 mm, 1000 mm (Russia $$$)
    - FL for legacy lenses: 250 mm, 500 mm, 600 mm, 800 mm, 1000 mm



Minolta RF Rokkor-X 250mm f/5.6, 1979

Concave primary mirror

Convex secondary mirror

Astrophotography and the 2017 Eclipse

Astrophotography

Note: Optimal pinhole diameter D = SQRT(L / 750) where L is the distance in millimeters from the pinhole to the paper → for L = 1000 mm, D = 1.2 mm

- Projection
  - Safest way to view and photograph an eclipse
    - Similar to camera obscura → tiny hole projects image on flat surface