Solar Eclipse 2017: Where to Go, How to Observe Safely

Prof. Patricia Reiff
Rice University
Solar Eclipse 101

• Who (will be able to see it?)
• What (is a solar eclipse versus a lunar eclipse)
• Where (do I need to go to see it best?)
• Why (do I need to go to totality?)
• How (do I observe it safely?)
• When (is the next one?)

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Solar Eclipse 101

• Who (will be able to see it?)

  – On August 21, 2017, EVERYONE in the continental US will be able to see at least a partial solar eclipse
  – Most will see 50% or more; Houston 66%
  – Millions will be in the path of totality!
  – The ONLY country that sees totality is the US!

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Solar Eclipse 101

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– Millions will be in the path of totality!


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Total solar eclipse of August 21, 2017

Eclipse magnitude is the maximum fraction of the Sun’s diameter occulted by the Moon.

Times given are for the moment of the local greatest eclipse.

1830 UT = 11:50 a.m. PDT = 12:50 p.m. MDT = 1 p.m. CDT = 2 p.m. EDT

http://www.greatamericaneclipse.com

Calculations by Xavier Jubier, update free hr
Predictions by Fred Espenak, wdc.cfa.edu
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Solar Eclipse 101

- What (is a solar eclipse versus a lunar eclipse)
  - A SOLAR eclipse is the moon casting its shadow on the Earth
  - A LUNAR eclipse is the Earth casting its shadow on the moon
  - Totality means the ENTIRE sun will be blocked by the moon, allowing us to see the corona

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Solar eclipse (from http://space.rice.edu/eclipse )

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Lunar eclipse (from http://space.rice.edu/eclipse )

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• What (is a solar eclipse versus a lunar eclipse)
  – Movie on solar versus lunar eclipse geometry:

http://space.rice.edu/eclipse/animation/flatscreen/EclipseGeometry_1280R264H.mp4
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• What (is a solar eclipse versus a lunar eclipse)
  – Movie of what a total solar eclipse looks like from Earth’s surface
  – Phases of the eclipse:
    First contact: Moon starts to cover Sun (beginning of partial phase)
    Second contact: Moon completely covers Sun (start of totality)
    Third Contact: Moon starts to uncover Sun (end of totality)
    Fourth Contact: Last bit of Moon leaves sun (end of partial phase)

http://space.rice.edu/eclipse/animation/flatscreen/SolarEclipse_Earth_1280R264H.mp4
• What (will you see?)

CORONA
The outermost layer of the solar atmosphere. The corona is made of a tenuous ionized gas called plasma, with temperatures up to many millions of degrees Fahrenheit. The corona is visible to the naked eye only during a total solar eclipse.

PROMINENCES
Structures in the corona made of relatively cool plasma supported by magnetic fields. Prominences are bright structures when seen over the solar limb, but appear dark when seen against the bright solar disk (where they're called filaments).

HELMET STREAMERS
Large, caplike coronal structures with long pointed peaks that usually lie over sunspots and active regions. These often have a prominence or filament at their base.

POLAR PLUMES
Bright structures of fast-flowing solar material coming from coronal holes, areas with magnetic field lines open to interplanetary space. Coronal holes are more common near, but not exclusive to, the poles.

CORONAL LOOPS
Found around sunspots and in active regions. These structures are associated with the closed magnetic field lines that connect magnetic regions on the solar surface.

Credit: S. Habbal, M. Druckmüller and P. Aniol
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• What will you see?
  – Movie of the Diamond Ring and Baily’s Beads as seen from Earth
    Last part of partial eclipse and beginning of totality

http://space.rice.edu/eclipse/animation/flatscreen/BailysBeads_1280R264H.mp4

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• Moon’s shadow from orbit
• (photo)
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- Moon’s shadow from orbit (animation)

http://space.rice.edu/eclipseanimation/flatscreen/SolarEclipse_Orbit_1280R264H.mp4

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• We recently had four total lunar eclipses in a row:
• Courtesy https://eclipse.gsfc.nasa.gov/
• Four total lunar eclipses in a row:
• Photos courtesy Brian Verkaart (Hawaii)
• Note darker at bottom (farther from edge of umbra)

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• In Houston *two* of these were *selenelions*: the eclipse at dusk or dawn so you can see the red sun AND the red moon at the SAME TIME. The sun’s red light passed over us and lit the dark moon!
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• Here is an animation of a lunar eclipse as seen from Earth:

• http://space.rice.edu/eclipse/animation/flatscreen/LunarEclipse_Earth_1280R264H.mp4

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• Here is an animation of a lunar eclipse as might be seen from the Moon: (note it is a SOLAR eclipse for the folks on the Moon)

http://space.rice.edu/eclipse/animation/flatscreen/LunarEclipse_Moon_1280R264H.mp4
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• If the Moon is too far away to cover the entire sun, we get an annular eclipse:

Annular eclipse (from http://space.rice.edu/eclipse)
Annular Eclipse
May 20, 2012
P. Reiff
Sandia Peak
Solar Eclipse 101

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• IF YOU POSSIBLY CAN, GO TO TOTALITY
• Try to be no more than 1-2 hours from center line and plan a location
• Expect HEAVY traffic - START EARLY!
• Don’t drive when sun > 50 % covered
• Find a hotel an hour away... those in totality are full or very expensive (e.g. Topeka KS is cheap)
Interactive Map from xJubier.free.fr – check your location’s times and coverage!

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Solar Eclipse 101

• Why (do I need to go to totality?)
  – Multisensory experience
  – Only way to see the diamond ring and corona
  – Shadows get sharp
  – Birds roost
  – Temperature falls, winds pick up
  – Clouds become more transparent
  – Each one IS different! Awe-inspiring!

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Why do I need to go to totality?

- Mul@ sensory experience
- Only way to see the diamond ring and corona
- Shadows get sharp
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- Clouds become more transparent
- Each one IS different!

Diamond rings I have seen

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  – Each one IS different!
NASA spacecraft do monitor the Sun, and by combining three images can give us an image of the sun’s inner and outer corona.
But nothing beats being there!!

CORONAL MASS EJECTIONS FIRST SPOTTED DURING A TOTAL SOLAR ECLIPSE (1860)

Left: Drawings of the 1860 eclipse by G. Tempel. Right: Modern-day instrument called a "coronagraph," which simulates a solar eclipse, blocking the sun to reveal the sun's outer atmosphere. Eruptions like the one depicted in Tempel's drawing are common observations in coronagraph images. Credit: ESA/NASA/SOHO
Solar Max coronas are more symmetric – this will be minimum so elongated

Corona Shape 2012 vs 2009

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  – Only way to see the diamond ring and corona
  – Shadows get sharp
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Celebrate!

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• “sunset” all around you (these are my fisheye images from various eclipses)

(China, 2008)
• “sunset” all around you
• Some stars and planets may be visible

(Australia 2012)
• This will be near-noon – best for the shadow and for shadow bands
• Moon shadow approaching at >1000 mph! (Libya, 2006)

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• Clouds become more transparent – we even saw Venus thru the thin clouds

(Ternate, 2016)

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• How (do I observe it safely?)
  – Eye protection KEY during partial phase
  – Special filters for binoculars and cameras
  – Only DURING TOTALITY is it safe to view with naked eye or unshielded binoculars
  – Projection techniques using binoculars or telescope
  – Pinhole cameras last resort (make a cardboard screen)

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How do I observe it safely?

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Safe observing!

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SAFETY IS KEY!
Download writeup from NASA site

How to View the 2017 Solar Eclipse Safely

A solar eclipse occurs when the moon blocks any part of the sun. On Monday, August 21, 2017, a solar eclipse will be visible (weather permitting) across all of North America. The whole continent will experience a partial eclipse lasting 2 to 3 hours. Halfway through the event, anyone within a 60 to 70 mile-wide path from Oregon to South Carolina will experience a total eclipse. During those brief moments when the moon completely blocks the sun’s bright face for up to 2 minutes 40 seconds, day will turn into night, making visible the otherwise hidden solar corona (the sun’s outer atmosphere). Bright stars and planets will become visible as well. This is truly one of nature’s most awesome sights.

A total solar eclipse is about as bright as the full moon — and just as safe to look at. But the sun at any other time is dangerously bright; view it only through special-purpose safe solar filters.

Looking directly at the sun is unsafe except during the brief total phase of a solar eclipse (“totality”), when the moon entirely blocks the sun’s bright face, which will happen only within the narrow path of totality.

The only safe way to look directly at the un eclipsed or partially eclipsed sun is through special-purpose solar filters, such as “eclipse glasses” (example shown at left) or handheld solar viewers. Homemade filters or ordinary sunglasses, even very dark ones, are not safe for looking at the sun. To date three manufacturers have certified that their eclipse glasses and hand-held solar viewers meet the ISO 12312-2 international standard for such products: Rainbow Symphony, American Paper Optics, and Thousand Oaks Optical.
Pinhole projection... punch a hole in a box and put a piece of paper in the other end

Pinhole image (dim)  ^

Image ^ from readers (bright)
Solar Eclipse 101

- How do I observe it safely?
  - Eye protection during partial phase
  - Special filters for binoculars and cameras
  - Only during totality is it safe to view with naked eye or unshielded binoculars
  - Projection techniques using binoculars or telescope
  - Pinhole cameras last resort (make a cardboard screen)

Pinhole makes dim image – too big is fuzzy; larger hole focused by readers is brighter
Fun way for a pinhole projection:
Punch holes in cardboard and photograph its shadow!
• Eclipse shades: cheap and easy! (But no magnification!)

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Binoculars have numbers: A x B means A magnification and B aperture.

• Binoculars with solar filters are the best for partial eclipses
• These pop off easily for totality.

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• When the filters are on, it can be hard to find the sun.
• First, CLOSE YOUR EYES and face the sun (feel it warm on your face).

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• Then bring the binocs (zoomed OUT) up to your eyes without moving your head... it should be in or near the field of view. Then zoom in.

• But, pain in the neck if it’s nearly overhead!

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• More comfortable and easier to share if on a tripod!
• Need solar filters for each lens (Rainbow Symphony)
• Need a “binocular tripod adapter” (photo store or Amazon)

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Binocular projection

- This eclipse will be HIGH IN THE SKY (near solar noon) for much of the US, and regular binoculars with solar filters will crane your neck.
- Solution: Binocs on tripod with adapter – one lens uncovered
- Align by minimizing the shadow of the binocs
- **DANGER:** Ensure that people don’t look through the binoculars!! Keep tripod very LOW to ground

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**Binocular projection**

- Ideally put the image into a shadow area and use white cardboard to project the image onto.
- **DANGER:** Ensure that people don’t look through the binoculars!! Keep tripod very LOW to ground.
- May heat up your binocs, so use a cheap pair that has the tripod mounting screw (zoom is good).
- Requires “binocular tripod adapter” available online (not sold in most stores)

reita@rice.edu
Binocular projection

- A drape makes a nice shadow (keep one lens uncovered)

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- Critical items:
  - Binocular tripod adapter
  - Solar filters
  - Tripod

Everyone should have their own binoculars for totality!!

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• “Sunspotter” – not cheap but VERY safe and all get a good view.
• Easy to align

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• “Sunspotter” even works for nearly-overhead sun.

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• H-alpha telescope: expensive but allows you to preview the prominences
Three safe ways demonstrated: filtered binoculars, binocular projection, and “Sunspotter”
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• Activities for groups:
  – Punching boards for pinhole pictures
  – Measure temperature
  – Sunspotter
  – Filtered camcorder on a TV to monitor progress
  – Reading chart (smallest font readable)
  – Photographing eclipses under trees, straw hats
  – Watching live video feed on NASA TV

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Solar Eclipse 101

• When (is the next one?)
  – Roughly 2 solar eclipses every year (but may be partial only)
  – Roughly 2-3 lunar eclipses each year
  – At least a partial lunar 2 weeks before or after a total solar eclipse
  – Next total in the US goes thru TEXAS, April 8, 2024!
  – (annular on Oct 23, 2023 also thru Texas)
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• When is the next one?

– Roughly every year 2 solar eclipses (but may be paral only)
– Roughly 2-3 lunar eclipses each year
– At least a paral lunar 2 weeks before or after a total solar eclipse

Next one in the US is in TEXAS, April 8, 2024!

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• PHOTOGRAPHY: Hard to get a perfect shot. Have to do range of exposures and put them together afterwards. Be sure you can manually set exposure and time, and TURN OFF FLASH!

• Short exposures see prominences and chromosphere
• Long exposures get the corona but overexpose the prominences

• PRACTICE WITH THE FULL MOON – GET DETAIL
• YOUR EYES WITH BINOCULARS IS THE BEST

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- VIDEOGRAPHY: Again, be able to change exposure (“iris”) and set manual focus to infinity
- Practice on the full moon
- Videocamera with LCD viewfinder panel is safe to take off filter just before diamond ring... and will show some corona with the ring (but might overheat if left on the sun past totality)
- Set up a videocamera so it captures YOU and the sun – your own reactions and sounds will be the most fun memory you have of the event.

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This is a multiple exposure digitally combined but gives the effect that your eyes see with binoculars.

Courtesy Druckmüller
www.zam.fme.vutbr.cz
• This is a multiple exposure digitally combined but gives the effect that your eyes see if the sky is very clear
- FIRST TIMERS: JUST ENJOY – don’t spend your totality behind a lens!!
- Always put filters closest to Sun
- Be careful with viewfinder cameras
- Be sure you can adjust exposure and focus
- Be sure you can turn OFF the flash!
- Practice on full moon
- No moving after 95% - you might trip over someone!
- Red flashlight!

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• This is a digitally combined image from several at various exposures.
• Courtesy Fred Espenak MrEclipse.com (from NASA download page)

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• More information:
  – http://space.rice.edu/eclipse
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• Solar Filters for binoculars:
  – http://www.rainbowsymphonystore.com/

• High quality photo filters from photo stores
  – E.g. online photo stores (B&H, etc)
  – Brick and mortar photo & astronomy shops

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Equipment Recommendations

• Best binoculars: Zoom 8-20 x 50 (ok: non zoom 10 or 12x 35 or 50) (check by looking at stars)

• Best camera: SLR with manual focus and exposure, 300mm or more telephoto (ok: digital camera with optical zoom, “sunset mode”). DO NOT USE DIGITAL ZOOM or FLASH

• Best camcorder: HD or 4K with manual focus and exposure option. (ok: other camcorders with LCD viewfinder). For groups, link to TV set or school video

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..........”Doctor Pat”, Rice University

reiff@rice.edu