How to observe today's eclipse safely

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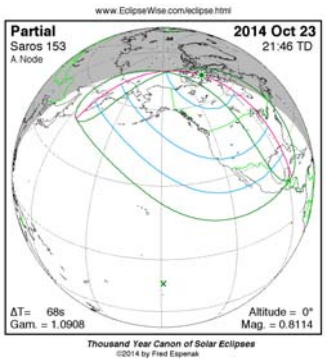
International Solar Eclipse Conference 2014
National Solar Observatory
23 October 2014



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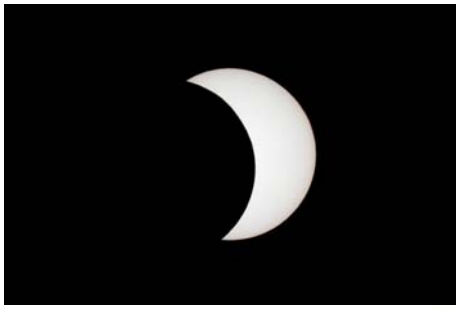
Partial Solar Eclipse



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Under the trees…

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Eye Hazards of These Events

- Well publicized by news media
- Attract a lot of curiosity seekers
- Astronomical tourism is a big industry
- Lots of misinformation on the internet

Solar eclipses and phototoxic retinopathy

- Keightley et al 2000
  - solar eclipse of 11 August 1999
  - 70 cases in United Kingdom
    - recognizable retinal lesions
    - all resolved over a period of weeks
  - eye protection
    - 35% sunglasses
    - 15% eclipse “glasses”
    - 50% no protection

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Solar retinopathy

- Presentation highly variable
  - slight visual loss to profound
- Recovery highly variable
  - >50% recover to pre-injury VA
  - unpredictable on basis of presentation

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Solar retinopathy

- Typical patient
  - young adult male (15 years +)
  - unaware of, or ignored warnings
  - no or inappropriate protection
  - first symptoms on morning after eclipse

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Solar retinopathy

- Painless
  - no pain sensors in retina
- Latent period
  - 12 to 48 h delay of onset of symptoms
  - wavelength dependent
- Visual recovery highly variable
  - depends on exposure conditions
- Optical aids increase severity
  - thermal effects add to photochemical

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Retinal exposure

- Unaided eye at sea level, air mass 1

Solar irradiance	70 $\mu W.cm^{-2}$
Sun angular subtense	9.3 mrad
Retinal image size	160 μm

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Retinal exposure

	2 mm pupil	3 mm pupil
Retinal irradiance	8 $W.cm^{-2}$	18 $W.cm^{-2}$
Retinal temperature increase	1.3° C	3.0° C
Threshold exposure	100 s	40 s

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Solar Retinopathy Mechanism of injury

Photochemical

- short wavelength light (blue)
- threshold 3 $W.m^{-2}$
- usually temporary visual loss
- most common type of injury

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Solar Retinopathy Mechanism of injury

Thermal

- long wavelength visible, IRA, extended short wavelength visible
- threshold 2.8 X 10^4 $W.m^{-2}$
- permanent injury with visual loss
- more common if optical aid was used

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Safe observing methods

- Indirect projection
  - Sunscope
  - Projected image from telescope
- Direct unaided
  - Solar viewers
    - Welder's filter SN 14
    - Aluminized polyester
- Direct with telescope
  - Objective filter

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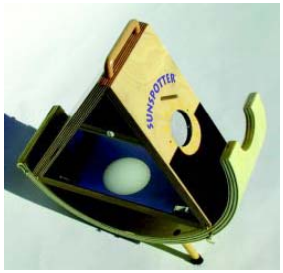
Sunspotter

- Folded refractor
  - 62 mm f/11
- White light image
- 3 kg



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Solar filters

- Shade No. 14 welder's filter
  - green glass or polycarbonate with gold coating
  - visual use only
- Aluminised polyester/resin
  - visual or photographic use

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Solar Eclipse Glasses

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Safety certification

- Solar eclipse glasses and filters certified as meeting transmittance requirements of EN1836 (European Standard for sunglasses and filters for direct observation of the sun)

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EN 1836

- Transmission and other requirements
  - Non-prescription sunglasses
  - Filters for direct observation of the sun
- Solar filter requirements introduced in 2005 by CEN
  - European Directive 89/686 Personal protective equipment
  - Mandatory compliance for sale in EEC

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EN 1836

Solar filter transmission requirements

Maximum luminous transmittance (τ_v)	0.0032%
Minimum luminous transmittance (τ_v)	0.000023%
Scale number range	12 to16
Maximum transmittance of solar UVB	τ_v
Maximum transmittance of solar UVA	τ_v
Maximum transmittance of solar IR	3%

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White Light observing/imaging

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Solar filters

- "Black" polymer
  - Carbon particles imbedded in polymer
  - Visual use only
- Metal coated glass
  - Inconel alloy on optical glass
  - Visual or photographic use

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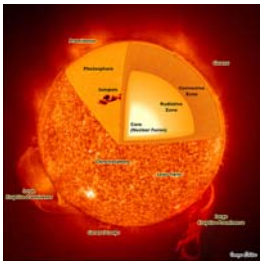
Hydrogen-alpha observation



- Red light of atomic hydrogen 656.3 nm
  - Chromosphere

http://www.flickr.com/photos/31904578@N07/2819311727/sizes/m/

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Hydrogen-alpha telescopes

- Requires special filter combinations
  - Energy rejection filter
  - Etalon
  - Blocking filter
- Originally very expensive until 1990s
  - Coronado filter system
  - Lunt system
  - Daystar system

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Coronado PST

- Less expensive alternative to SolarMax filters
- Tripod mounted dedicated telescope
- H-alpha (656 nm) and Ca-K (393 nm) models

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H-alpha image (656.3 nm)

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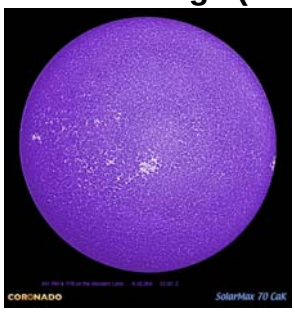
Calcium K-line image (393.37 nm)



http://www.coronadofilters.com/QuickGal/QuickGal.php?album=PST+CaK/

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