

How to Observe the Sun

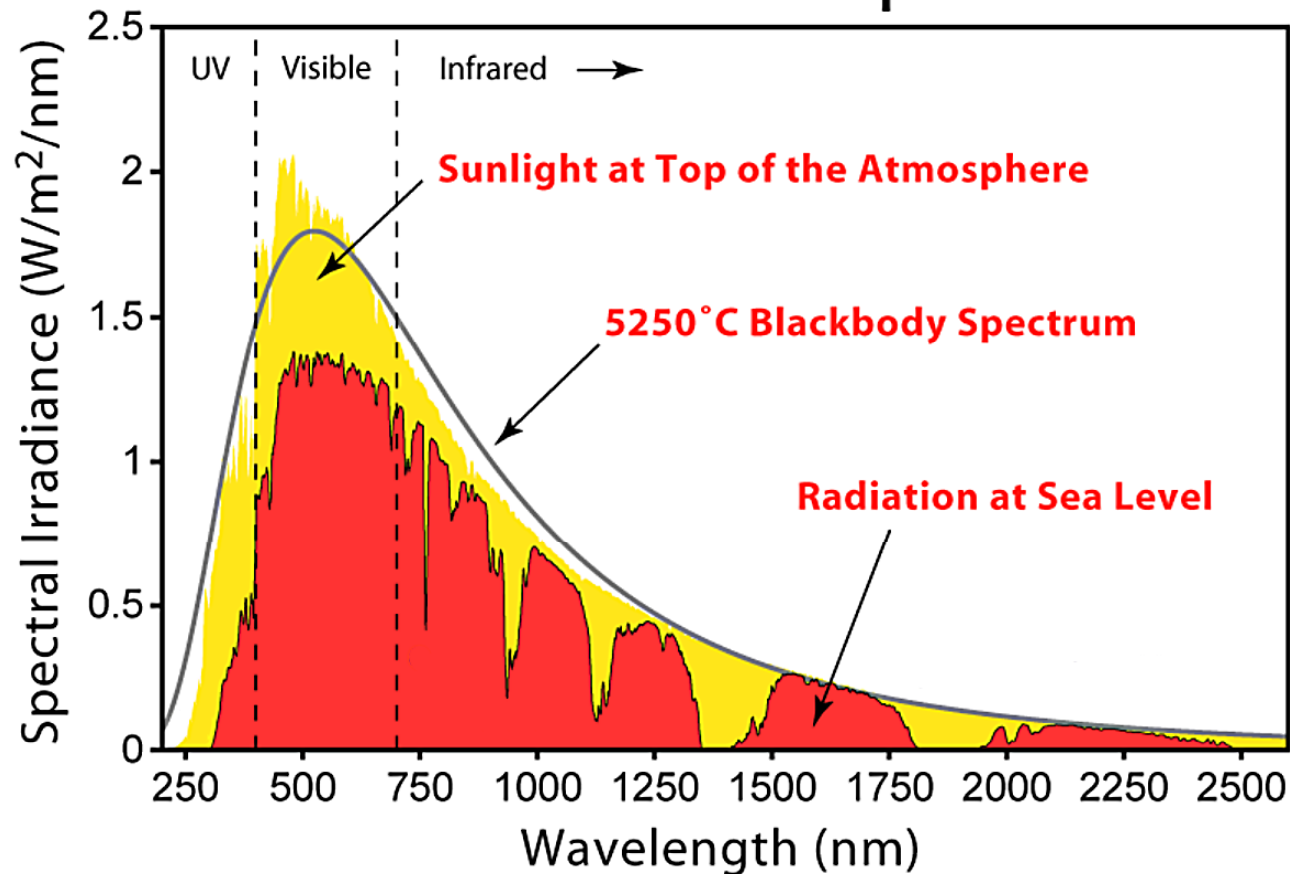
An excerpt from OAWS#16



By Jim Thompson
Spring 2017

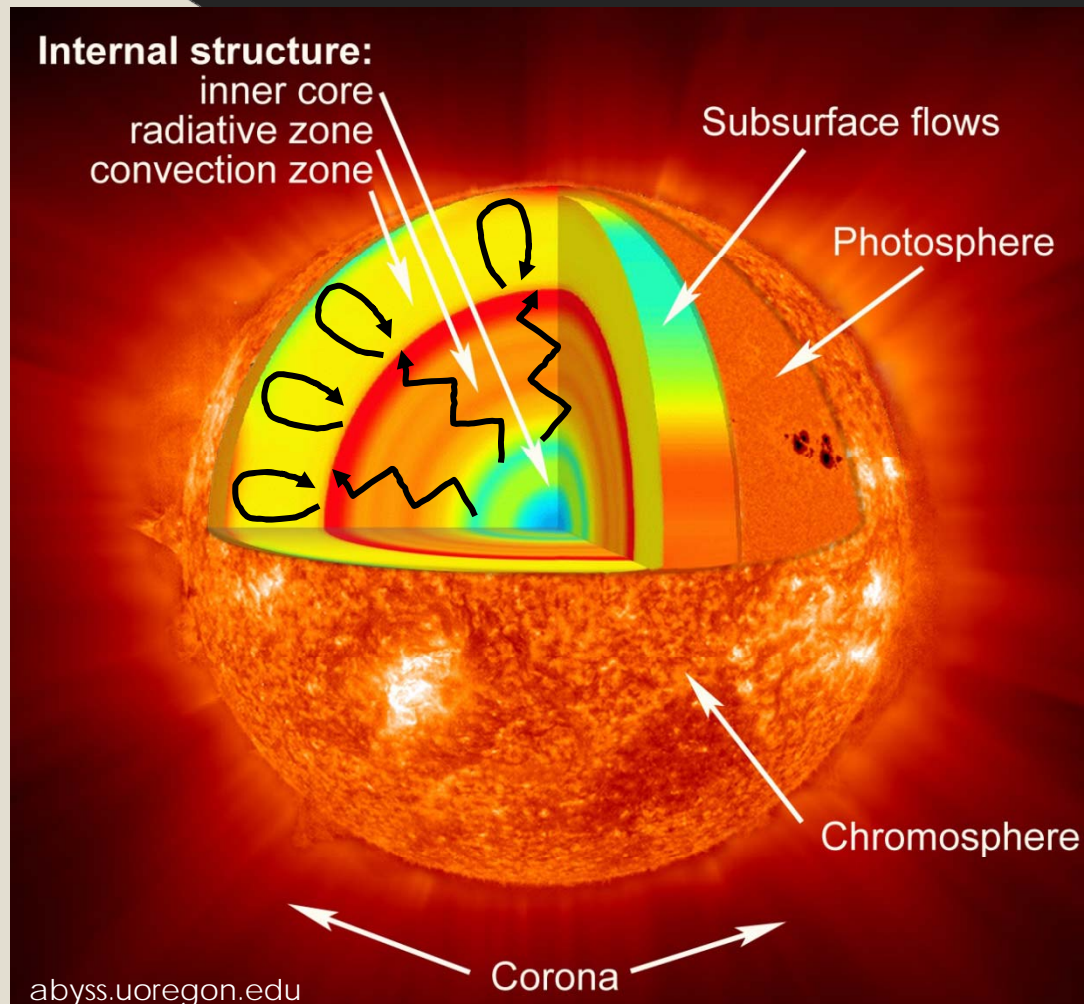
Be Safe!

Solar Radiation Spectrum



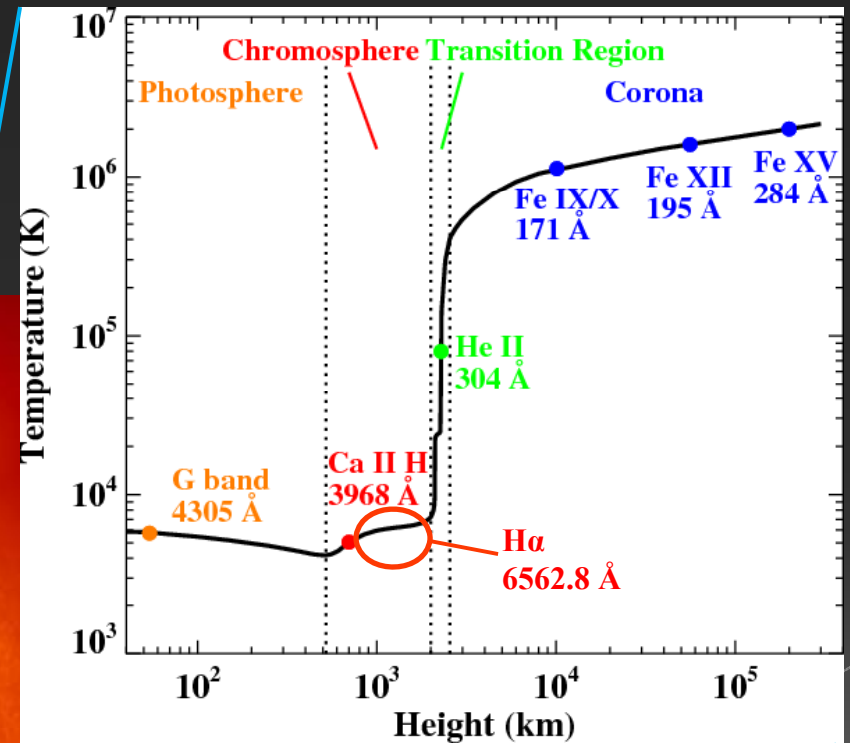
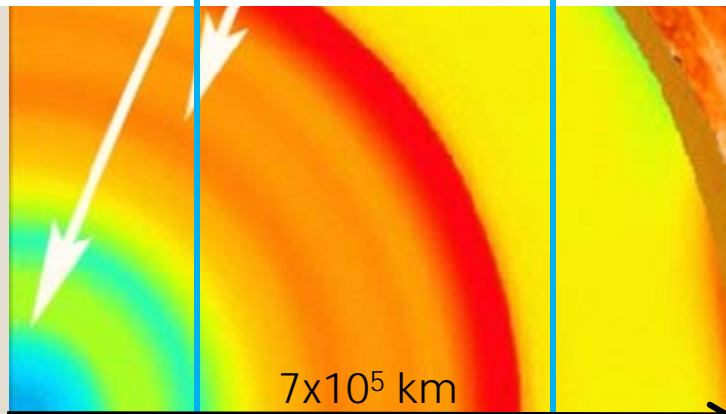
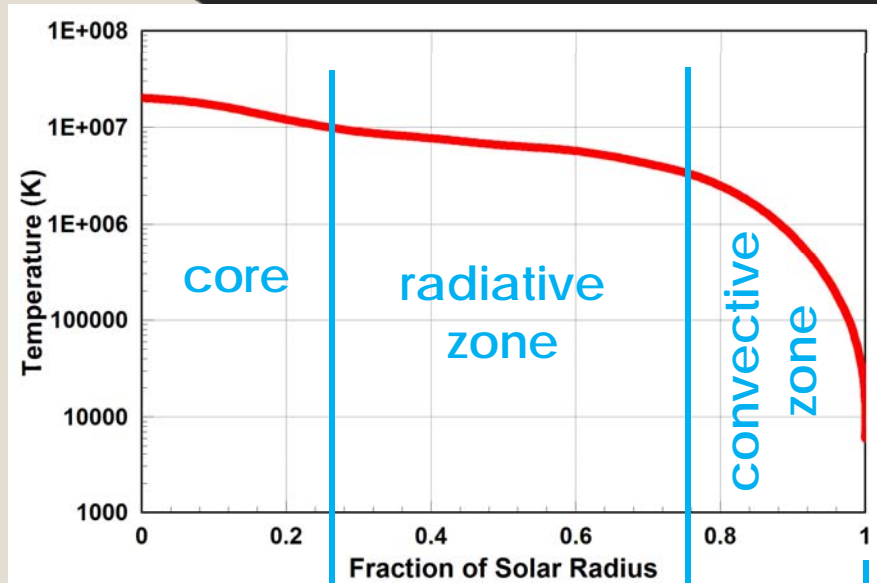
- $> \frac{1}{2}$ of Sun's energy is infrared
- without proper protection you're literally **cooking your eyes!**

Anatomy of the Sun



- ◉ INTERIOR:
 - > CORE: **fusion engine** ($25\% R_{\text{sun}}$)
 - > RADIATIVE: ($25\text{-}75\% R_{\text{sun}}$)
 - > CONVECTIVE: ($75\text{-}100\% R_{\text{sun}}$)
- ◉ EXTERIOR:
 - > PHOTOSPHERE: photons are finally free, what we see (peak emission)
 - > CHROMOSPHERE: active lower atmosphere, neutral H exists, less bright than photosphere
 - > CORONA: low density upper atmosphere, much hotter than photosphere, much less bright than photosphere
- ◉ 1kyr to 1Myr for a photon produced in the core to make it to the photosphere

How Hot is the Sun?



How To Observe Sun's Layers

- ◉ Interior = leave for NASA & ESA
(unless you want to build neutrino detector in your basement)
- ◉ Photosphere = white light
- ◉ Lower Chromosphere = calcium II - K
- ◉ Mid-Upper Chromosphere = hydrogen II - α
- ◉ Corona = total solar eclipse (naked eye)

White Light Observing

- view visual band at safe intensity
- several options available – use existing scope
- most economical way to observe Sun

britastro.org/mercury2016



Rear Projection

- project image onto white background
- many people view at same time
- not the best image – see sunspots only
- use a junk eyepiece! (will get cooked)
- cheapest solution

www.starizona.com,
www.365astronomy.com



Solar Filter

- glass or thin film blocks 99.999% of light
- attach over front of scope
- larger scopes use part-aperture
- improved image – sunspots & some granulation
- reasonably affordable solution

naked eye solar glasses ~\$0-20

www.flickr.com/photos/alexandra4
Alexandra Hart

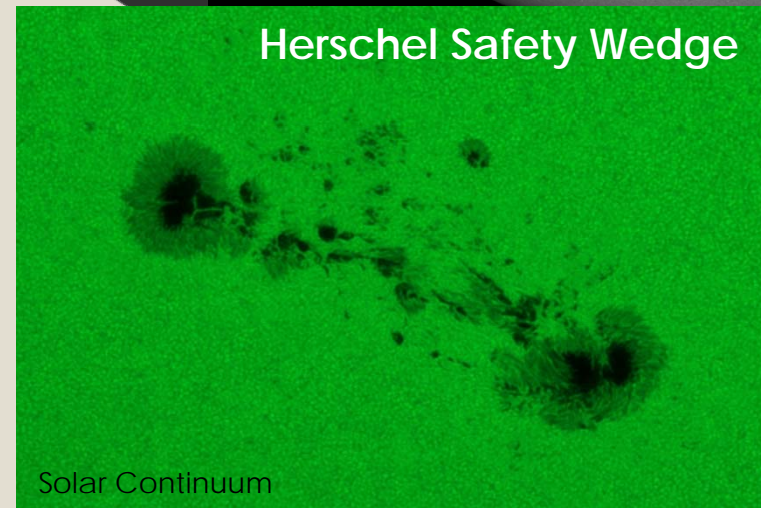
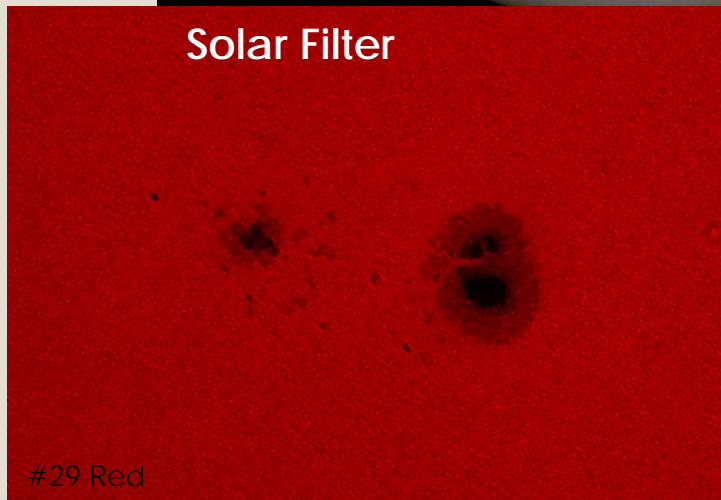


Herschel Safety Wedge

- wedge prism directs 4.6% to eye, rest out back
- insert into focuser, then eyepiece into wedge
- refractors only, 6" or smaller
- best image – lots of sunspot & granule detail
- most expensive solution (\$800 CAD)

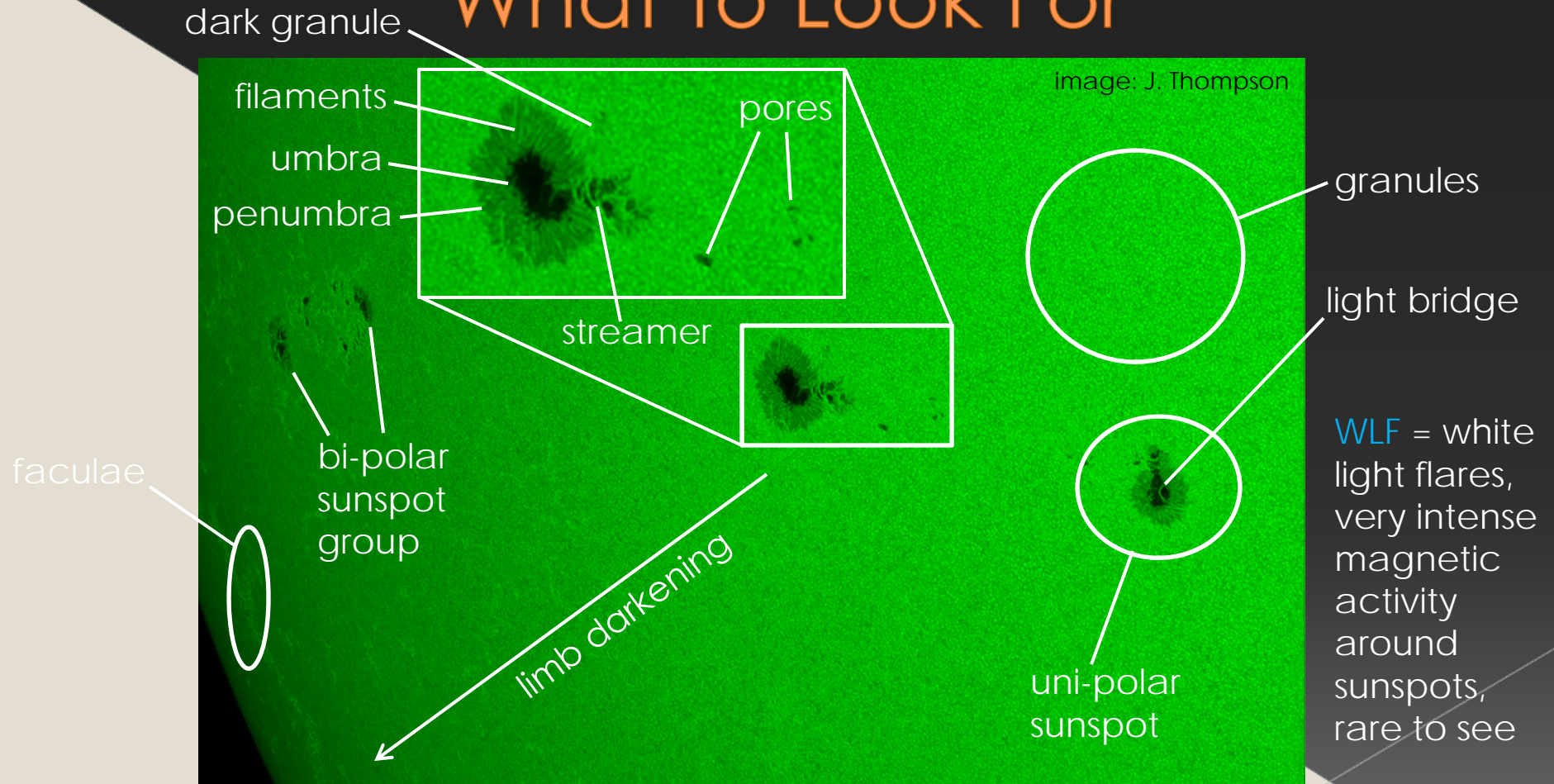
White Light Observing – Examples

all images: J. Thompson



What to Look For

Image: J. Thompson



- **SUNSPOT**: concentration of magnetic field lines, disrupts convection so cooler, often in pairs N-S
- **FACULAE**: local bright spots between granules, due to decreased magnetic activity, see easier at limb, linked to sunspot formation

- **GRANULES**: visualization of convection cells in photosphere, light-hot-rising, dark-cool-sinking
- **LIMB DARKENING**: gradual solar disk darkening as you move towards limb, optical affect

- **PORES**: small dark spots, start granule size in areas with faculae, larger ones may grown into sunspots
- **LIGHT BRIDGE/STREAMER**: bright band cutting into umbra & sometimes penumbra, usually thin

Calcium II-K Observing

- view narrow (0.5-80Å) band in NUV (393-398nm)
- use your existing scope + ERF (energy rejection filter)
- expensive way to "observe" Sun - **camera only!**



Screw-On Filter

- most affordable of methods (\$350)
- provides good images but not "the best"
- very flexible to use



Fixed Etalon

- etalon typically gives more accurate band pass than screw-on filter
- "can" give sharper image than screw-on
- only Lunt Ca-K module available, Coronado PST no longer for sale
- relatively expensive (\$800-2000)

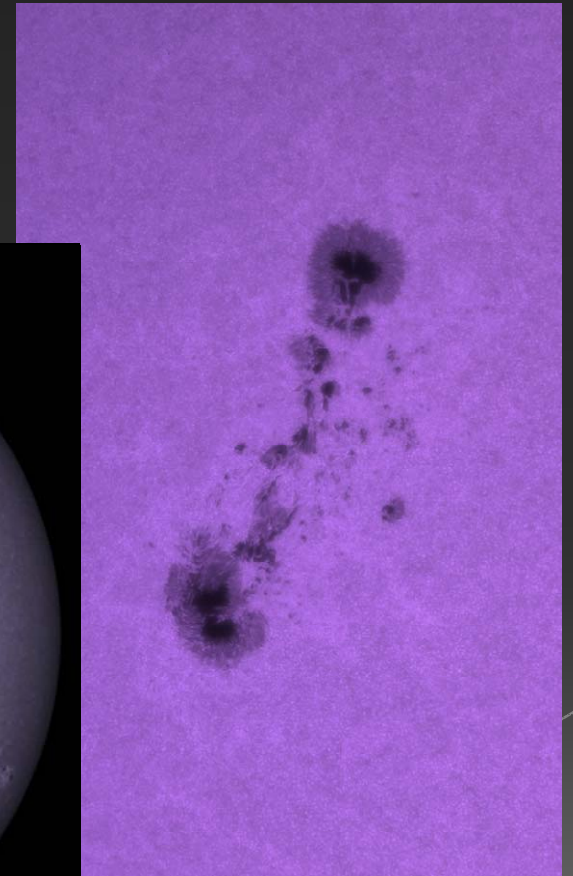
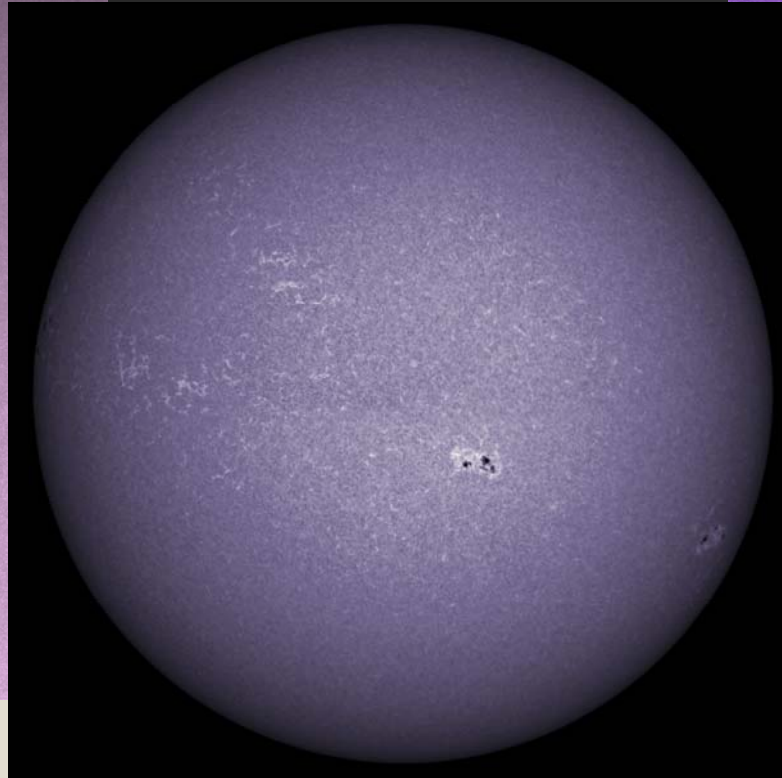
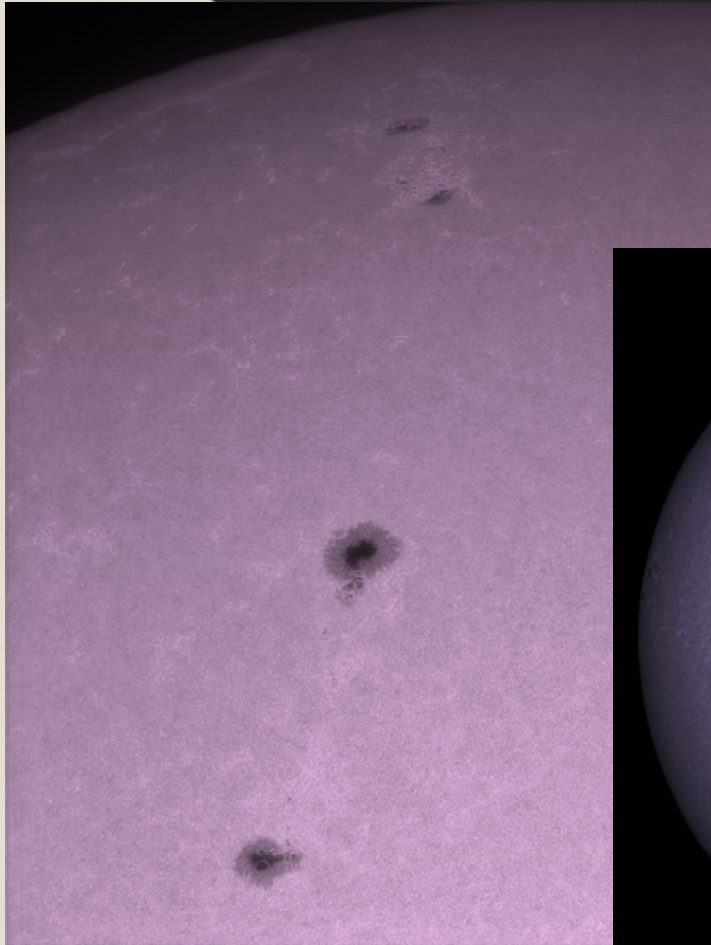


Adjustable Etalon

- use very accurate temperature controlled etalon
- provides excellent detail
- very expensive! (\$1200 - 6000)

Calcium II Observing – Examples

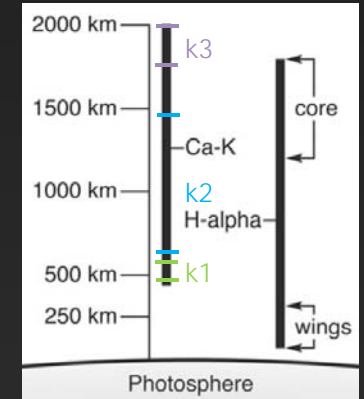
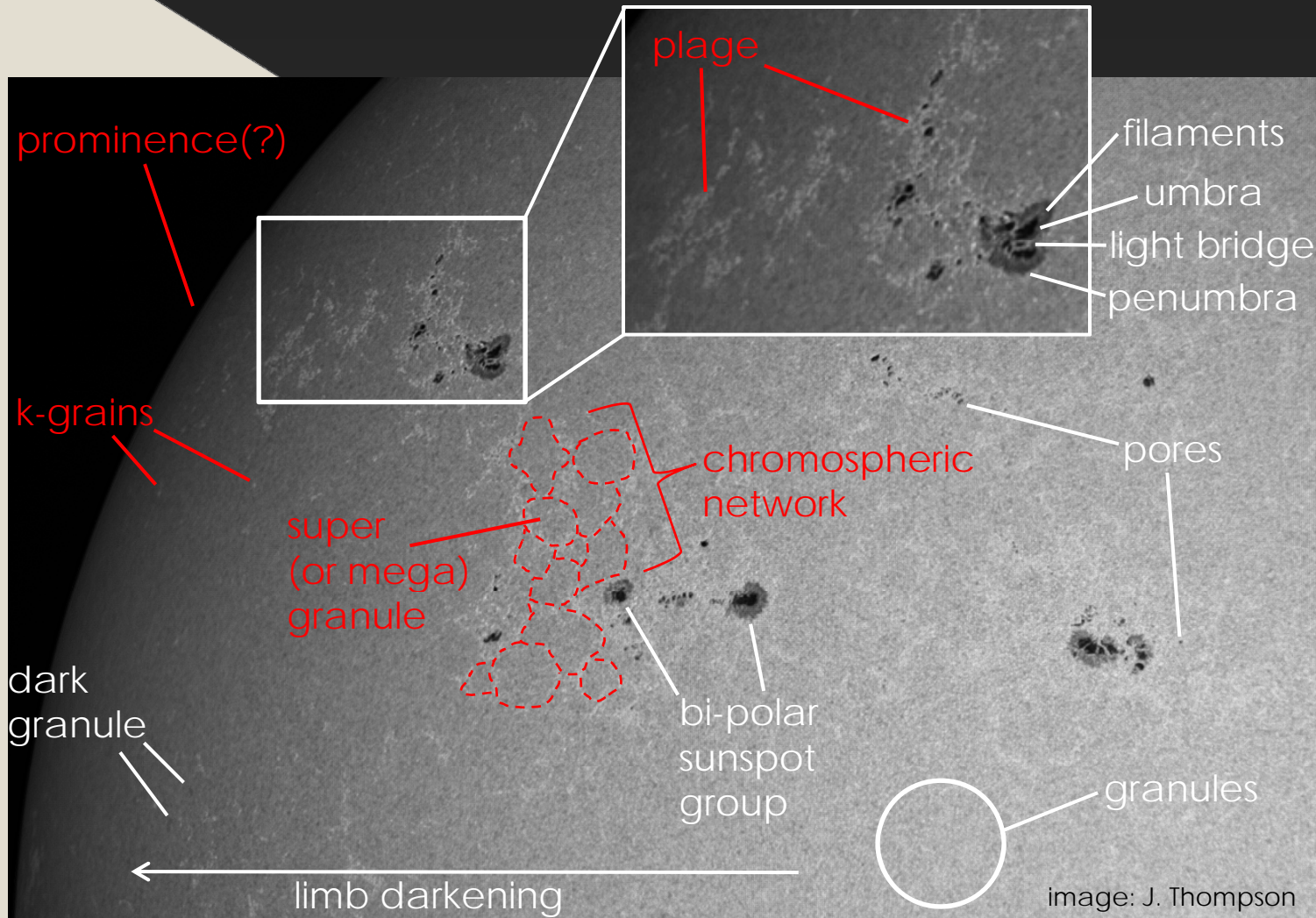
Baader Herschel Wedge
+ Omega Optical Ca-K



all images: J. Thompson

What to Look For

Jamey L. Jenkins,
Observing the Sun: A Pocket Field Guide



Most Ca-K filter systems
are K1-K2 sub-band

- **K-GRAINS**: small bright points, away from other activity, within middle of super granule, short lived (~10min)
- **PLAGE**: French for "beach", patchy bright regions w/ higher temp., found most often near sunspots, visible predominantly in Ca-K, mark area of increased magnetic activity, connection to faculae unclear
- **CHROMOSPHERIC NETWORK**: weak but bright background pattern, overlays super-granules in photosphere (large scale convective pattern), last day or so
- **SUPER GRANULE**: single cell within network, ~30,000km size

image: J. Thompson

Hydrogen II- α Observing

- very narrow (0.3-0.7Å) band in dark red (656.28nm)
- all options require tuneable etalon
- most expensive way to observe Sun - & most interesting!



Tilt Tuned Etalon

- tuning of waveband achieved by finely adjusting angle of etalon (thumbscrew or pressure)
- etalon paired with blocking filter
- can stack etalons for better contrast
- use with existing scope – refractor only
- \$1000-8000

much cheaper DIY tilt-tuned possible but poor performance



Dedicated H α Scope

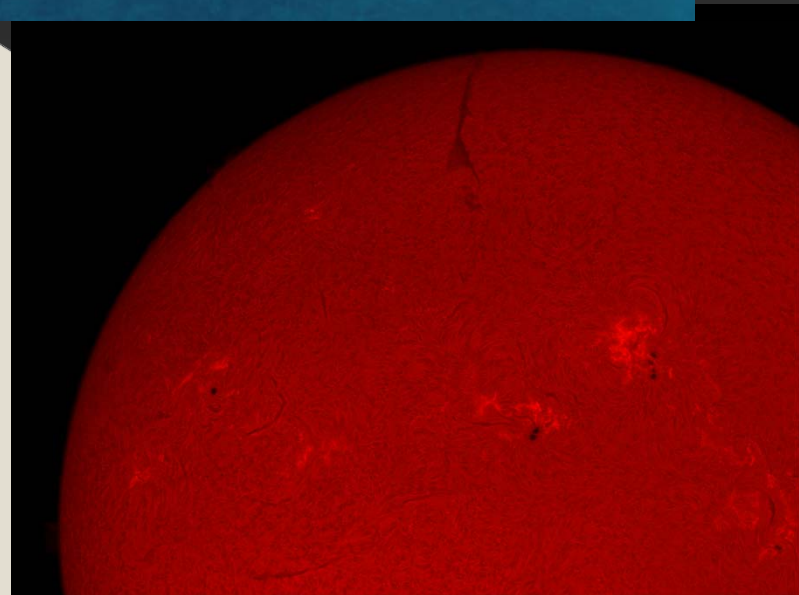
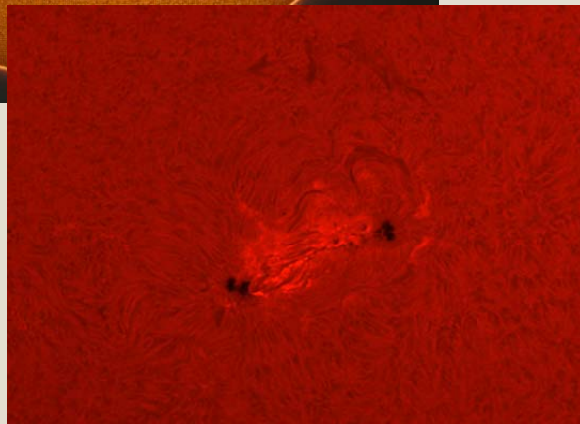
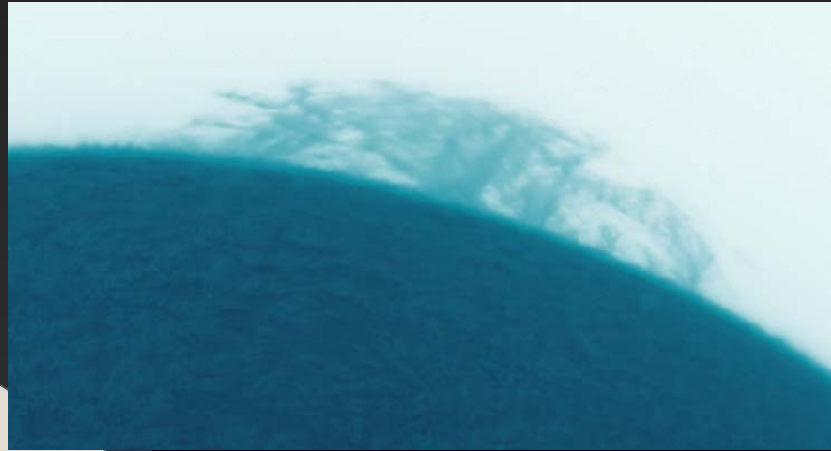
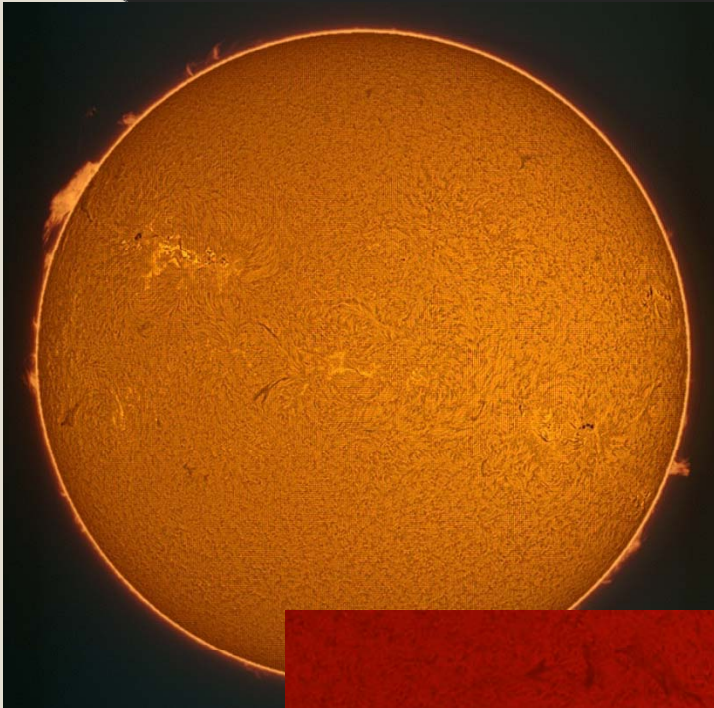
- same tilt tuning & blocking filter as when buy etalon separately
- can stack etalons for better contrast
- can only use scope for solar viewing
- \$1200-10,000



Temp. Tuned Etalon

- use very accurately controlled etalon (changes thickness with T)
- provides excellent detail
- very expensive! (\$1200 – 16,000)

Hydrogen II- α Observing – Examples



all images: J. Thompson

What to Look For

- **SPICULES**: individual jets of hot gas, moving vertically at up to 50,000 kph, last ~10min
- **FIBRILS**: spicules that are stretched & distorted by nearby magnetic activity (sunspot)
- **PROMINENCE**: cloud of gas above surface
- **FILAMENT**: a prominence viewed from above
- **FLARE**: sudden extreme release of energy stored in magnetic field of an active region

- **EMERGING FLUX REGION**: area of increasing magnetic activity (growing plages, start of sunspots)
- **ARCH FILAMENT SYSTEM**: kind of fibril in active regions, joins areas of opposite magnetic poles

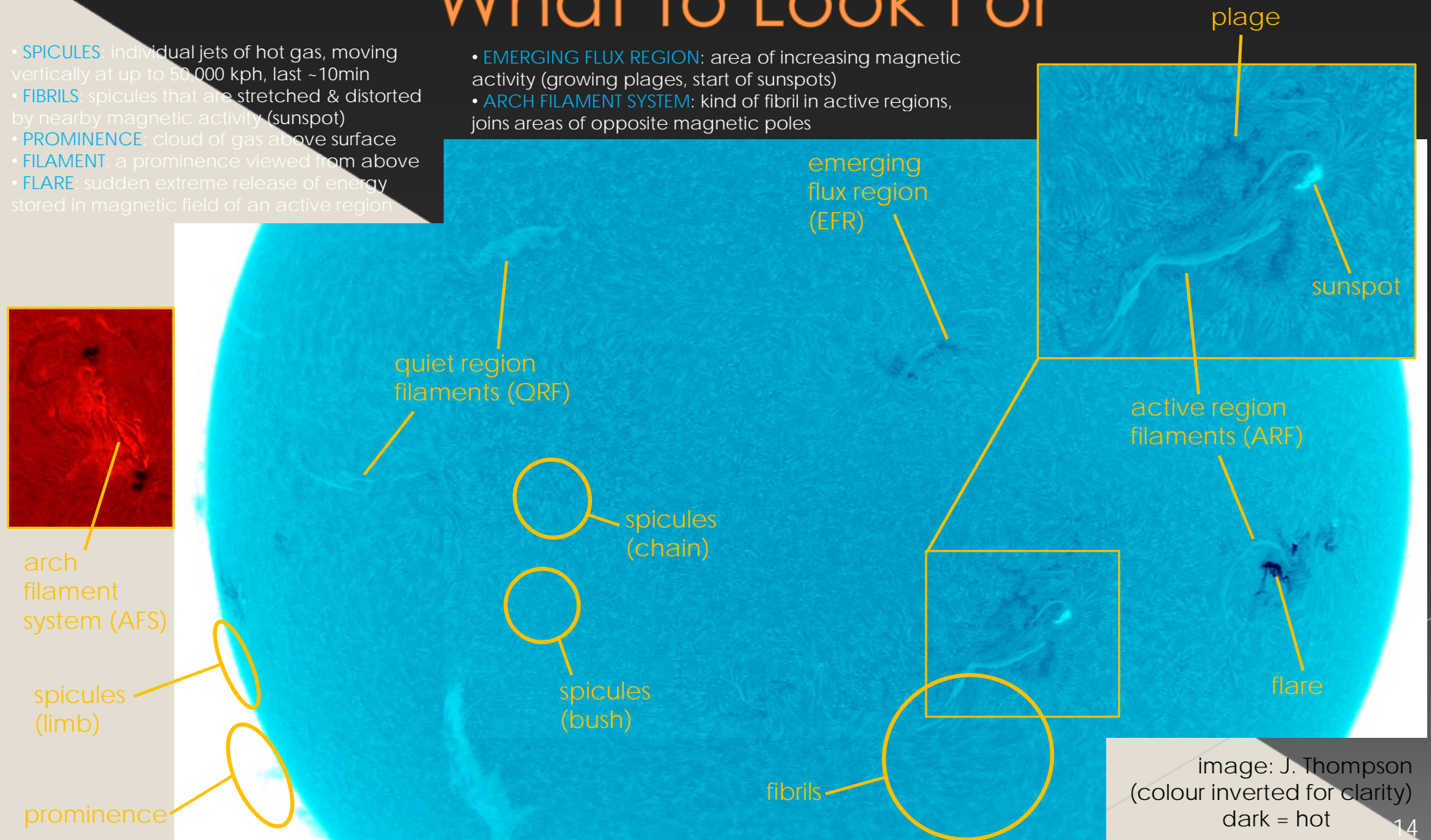
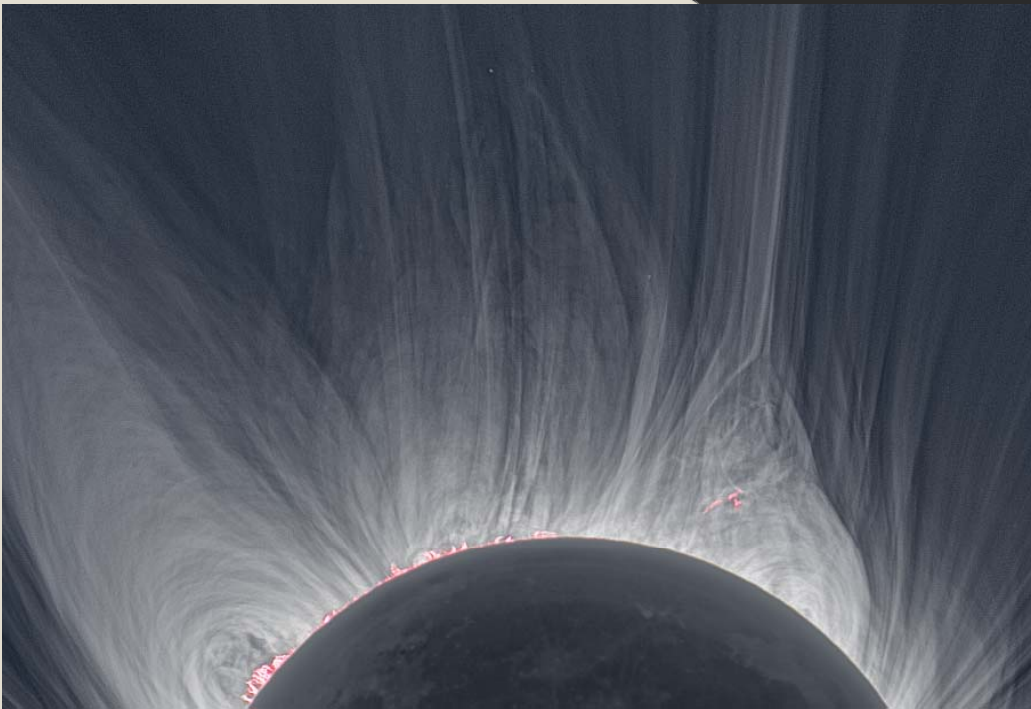


image: J. Thompson
(colour inverted for clarity)
dark = hot

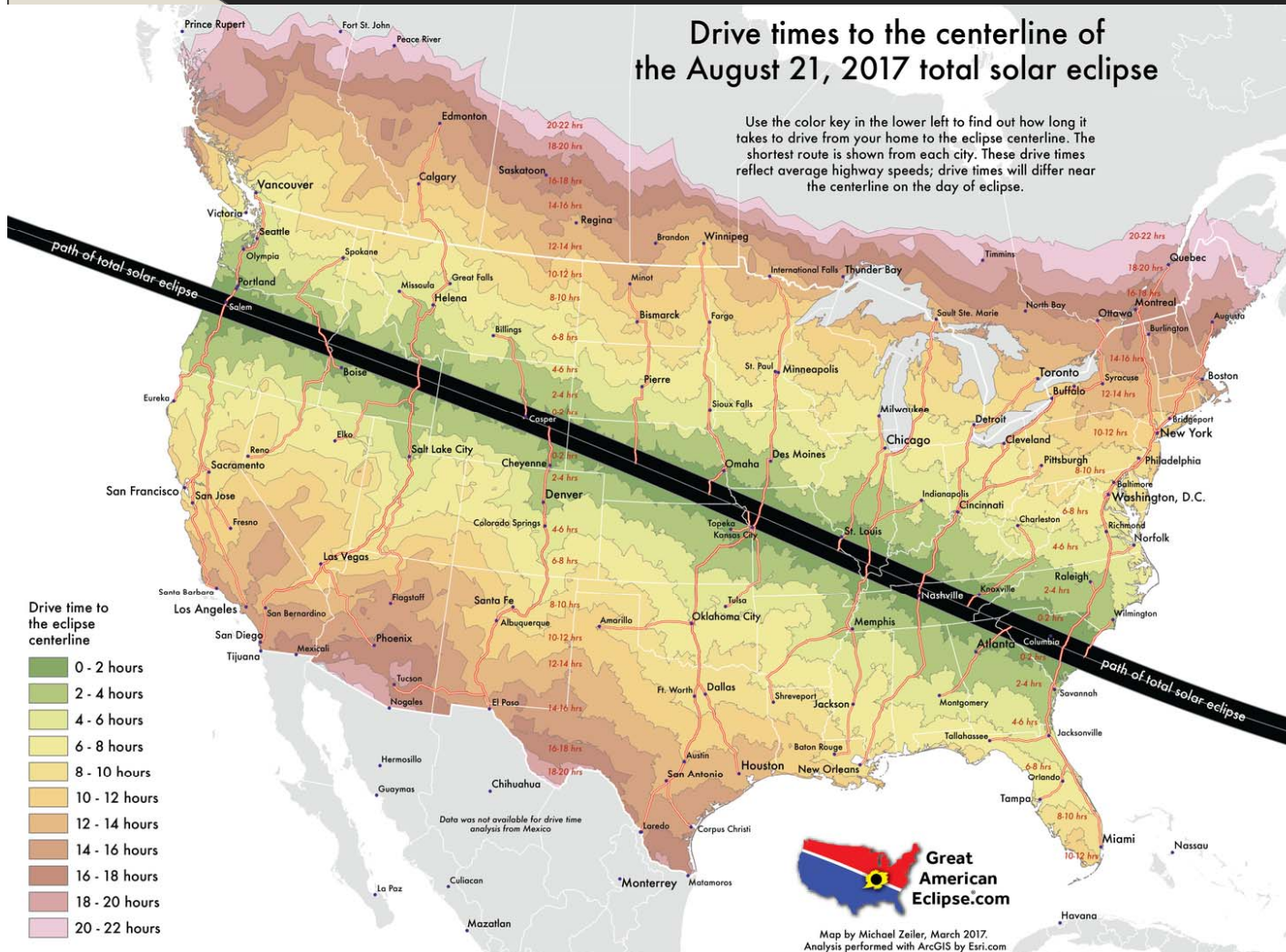
Corona Observing

- 1/1,000,000th as bright as photosphere
- only opportunity to observe is during total eclipse
- no filters req'd, chromosphere visible also



Both images: Miloslav Druckmüller

Totality or Bust



- Ottawa two day's drive from path of totality
- If you plan on making the trip, but haven't made plans yet...**may be too late**
- Next driving distance total eclipse: April 8, 2024, St. Lawrence Seaway

Questions?

