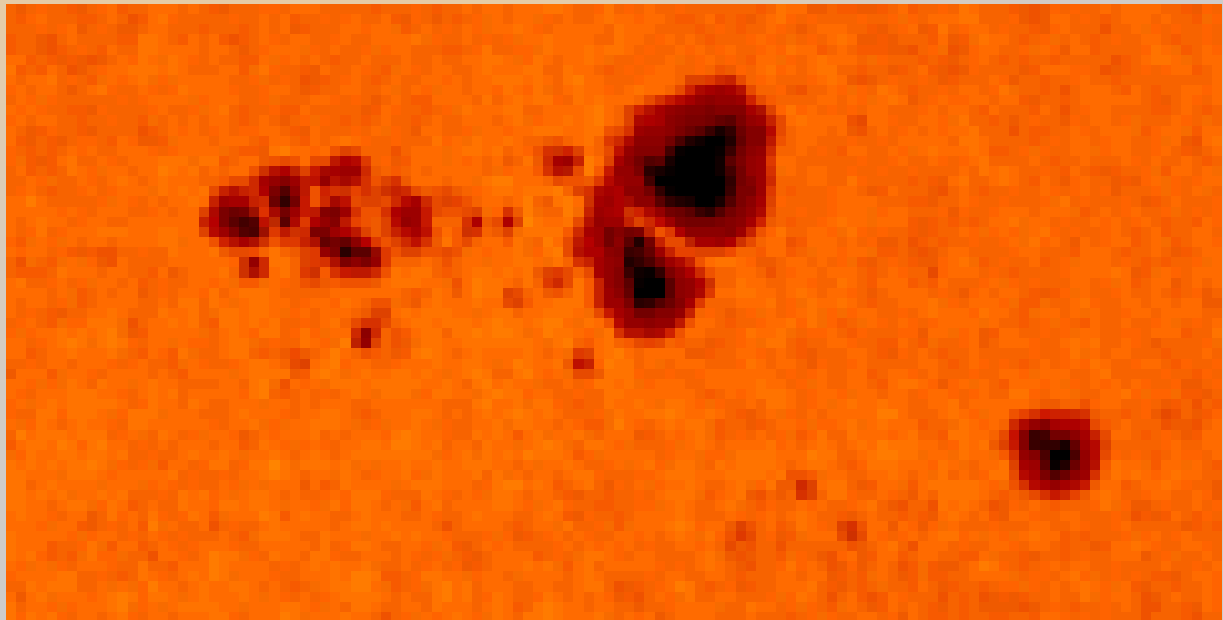
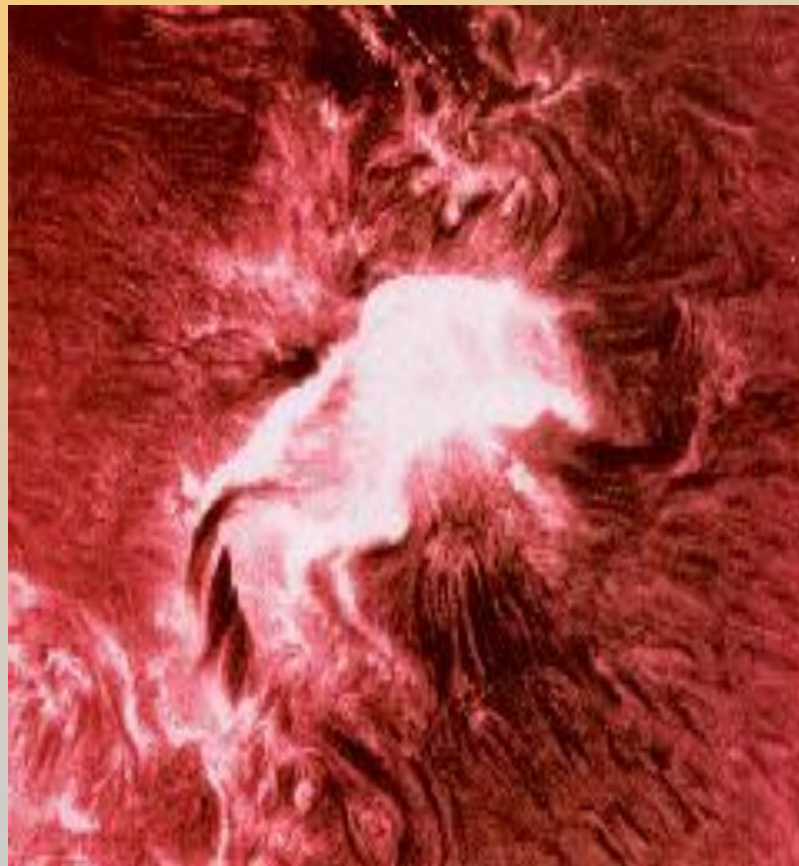


*Sunspots, Solar Cycle,
and Observing the Sun*





What We Don't Know



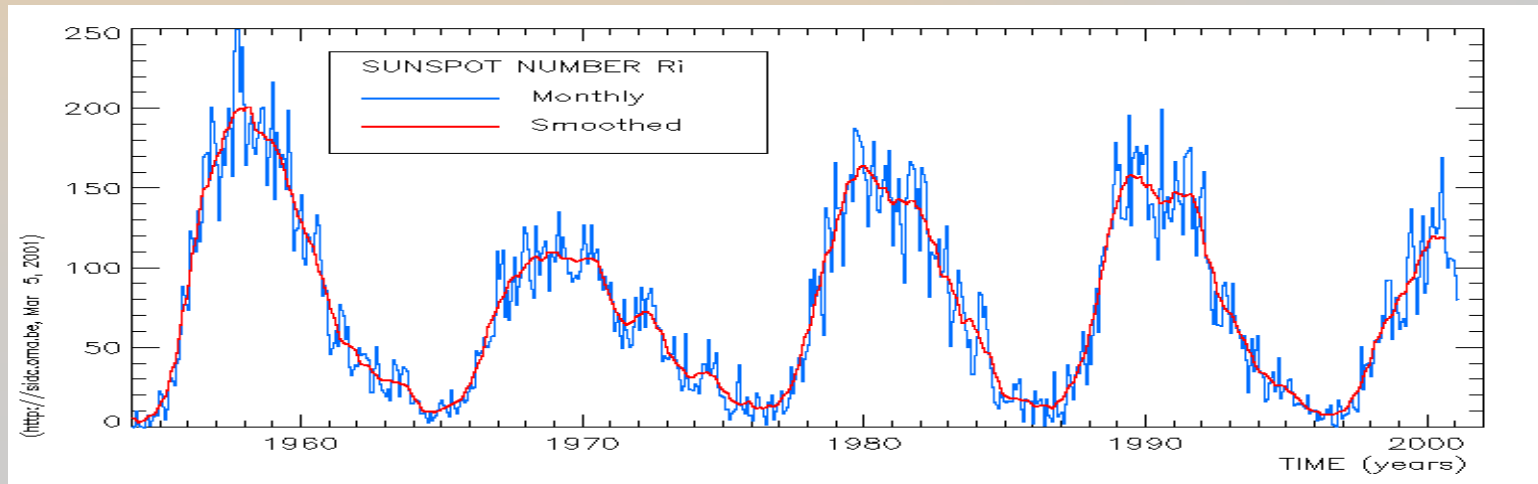
- ★ What are the precise causes of flares and CMEs?
- ★ Why do sunspots cycle in an 11 year cycle?
- ★ Why is the corona is hotter than the photosphere?



Solar Sunspot Cycle

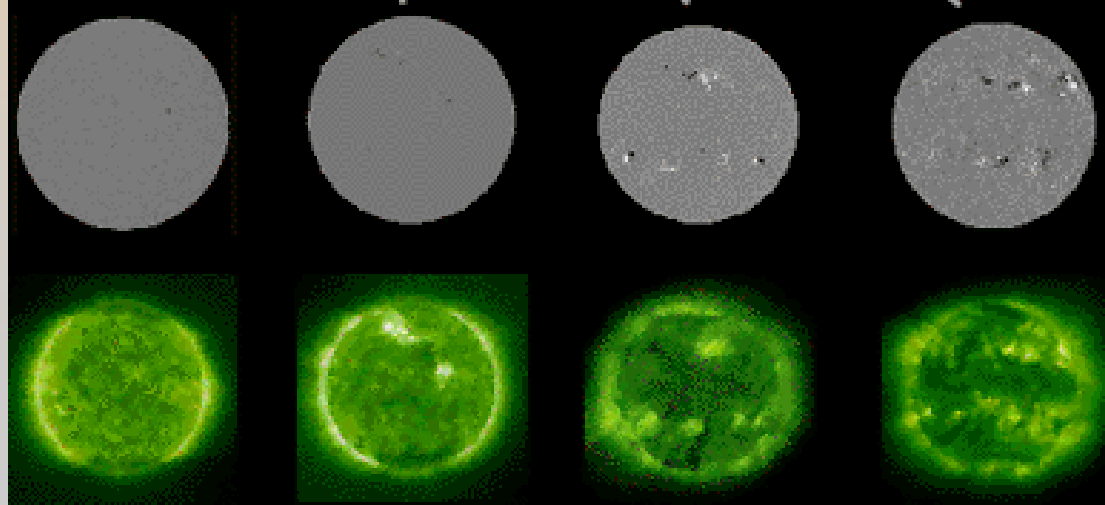
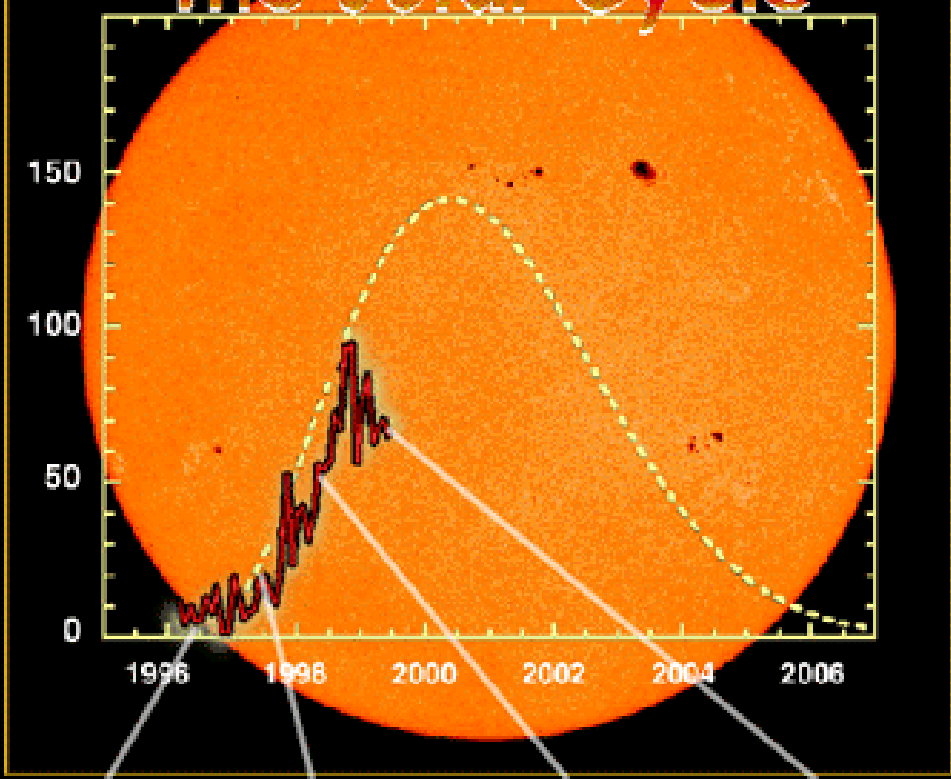


- ★ The sun spot count peaks every 11 years
- ★ Astronomers don't know why, but suspect:
 - magnetic processes within the sun run an 11-year cycle
 - planetary gravitational influence (Jupiter's orbit = 11.86 years) {this is a less probable consideration}



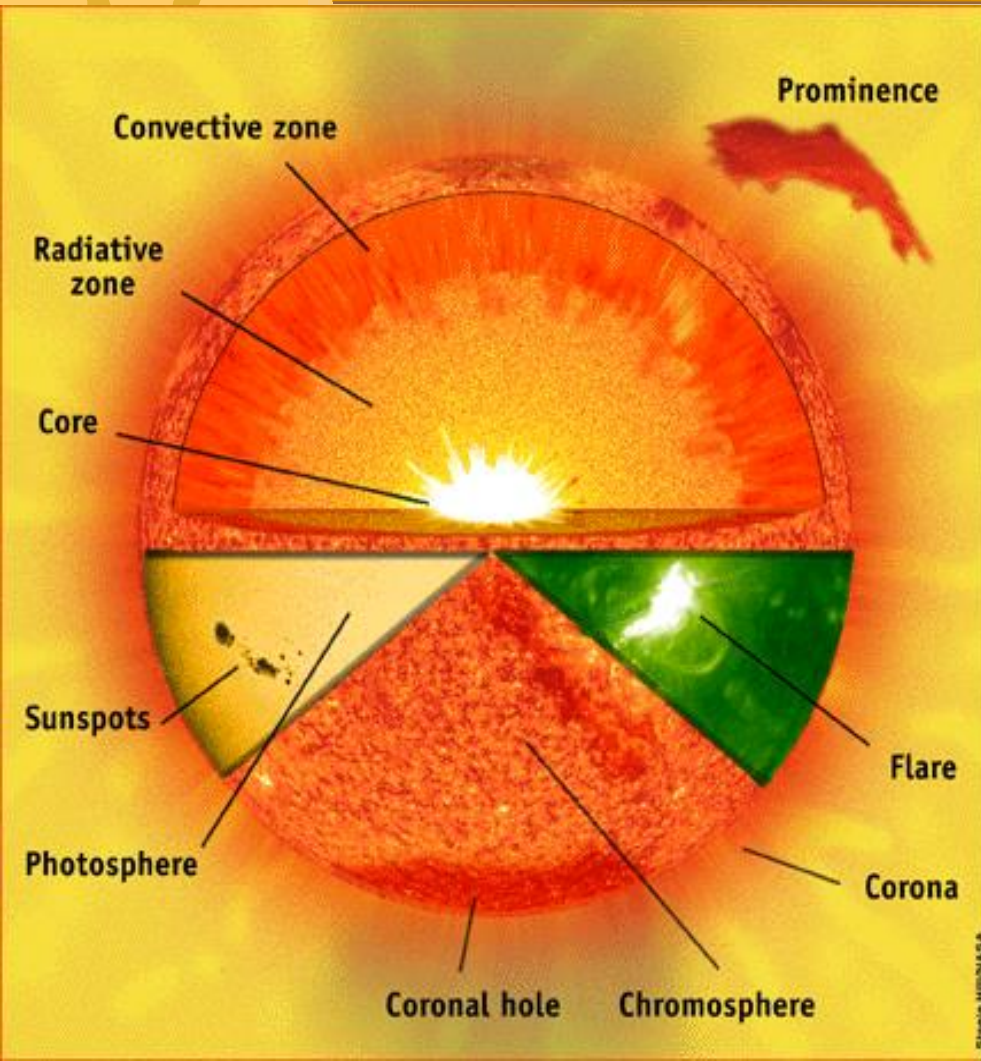


The Solar Cycle





How are Sunspots Born?

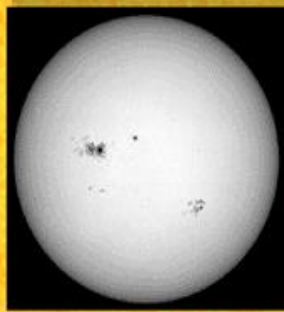


1. Many layers of the sun spin at different rates, creating a magnetic field for the sphere
2. Convection currents create local magnetic fields in hot gas bubbles
3. Larger local magnetic fields and bubbles rise to the surface
4. At the surface, north and south polarity are split into pairs of disturbances
5. Large pairs usually create sunspots
6. Large sunspot groups often create flares and mass coronal ejections



Sunspot Anatomy

September 23, 2000



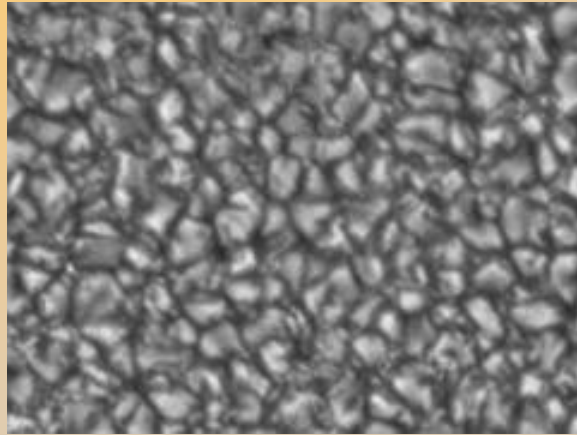
- ★ Granulation – 1-2 arc sec size
 - Tops of convection cells
 - spread throughout the surface
- ★ Pores – ↓1 arc sec dark areas
 - can develop into sunspots
- ★ Umbra – dark area of sunspot, most active area
- ★ Penumbra – lighter fringe found on larger sunspots
- ★ Faculae – ↑1 arc min light areas surrounding sunspots



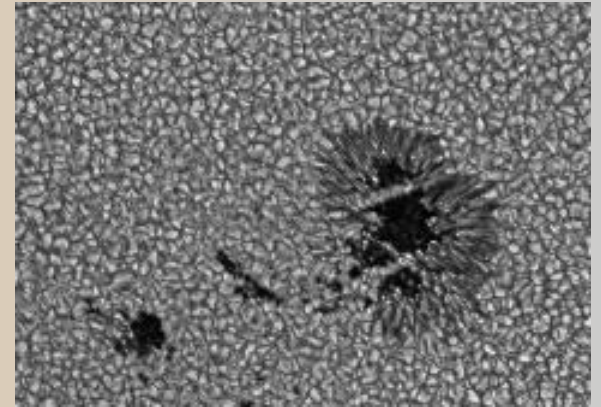
Size of Earth (approx.)



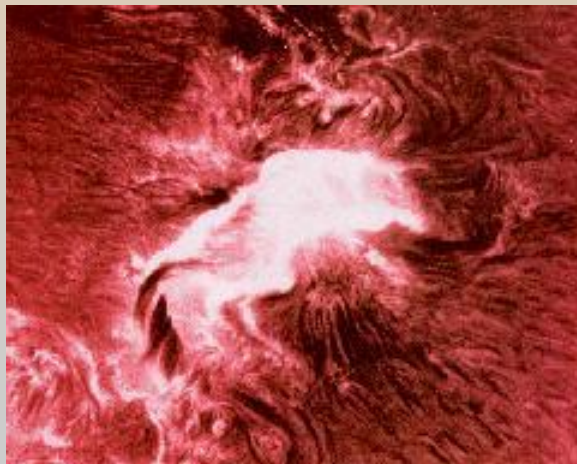
Close-ups of Features



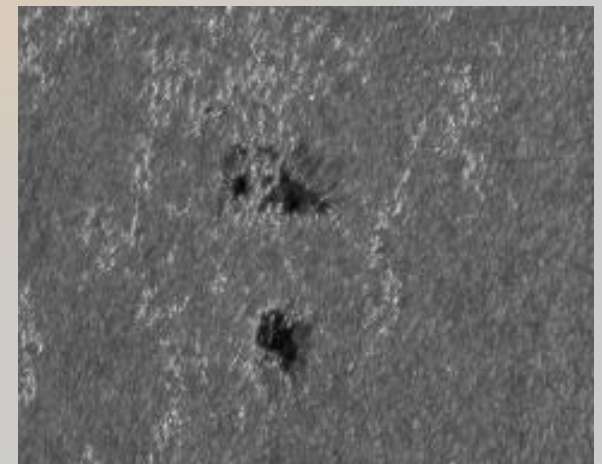
Granulae



Sunspot



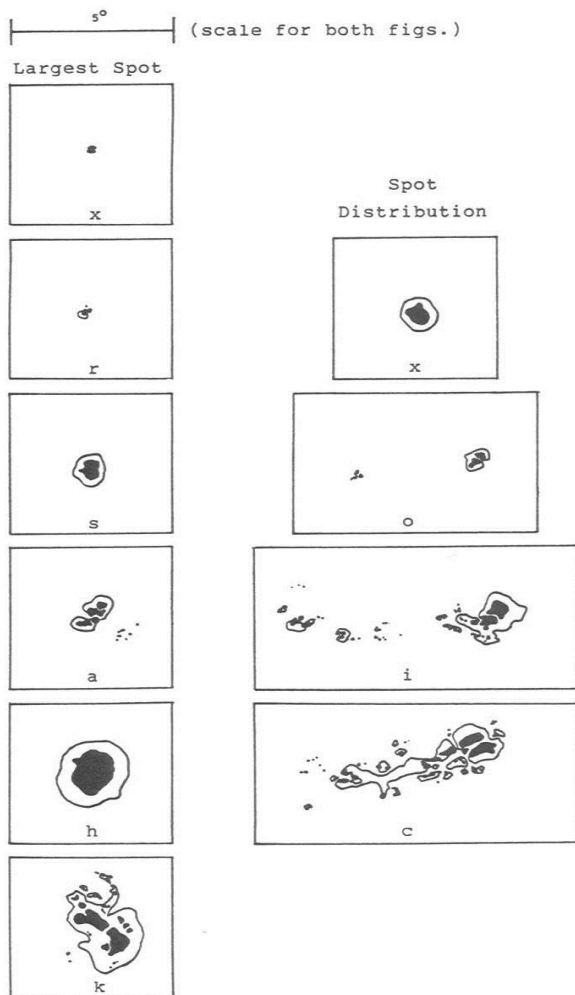
Flare



Faculae



Sunspot Classification & Flares



- ★ Measured in solar degrees
- ★ First column describes the largest (or only) sunspot of the group
- ★ Second column describes the layout of the group itself
- ★ This categorization allows astronomers to accurately predict solar flares
- ★ Classifications Fsi, Fki, and Fkc carry a 100% probability of an M flare within 24 hours!
- ★ Classification Fkc also carries a 50% probability of an X (X-ray) flare.
- ★ Surpasses all other prediction methods and classifications.
- ★ Groups that produce flares are relatively rare, except during solar maximum



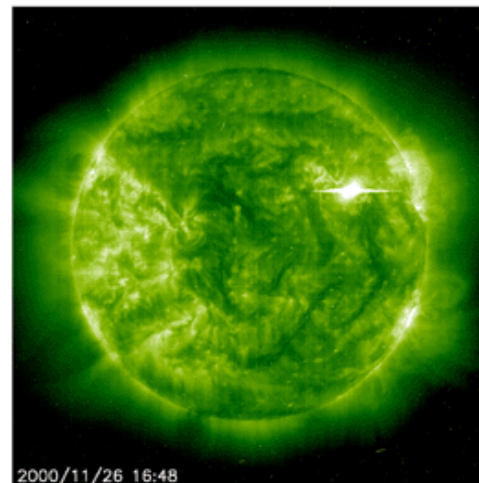
Sunspots, Flares, and CMEs



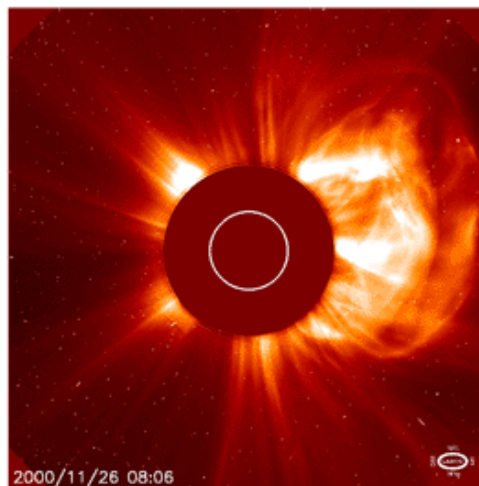
MDI



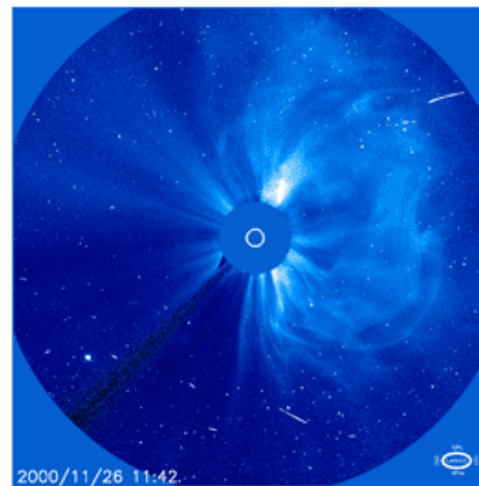
EIT



LASCO
C2

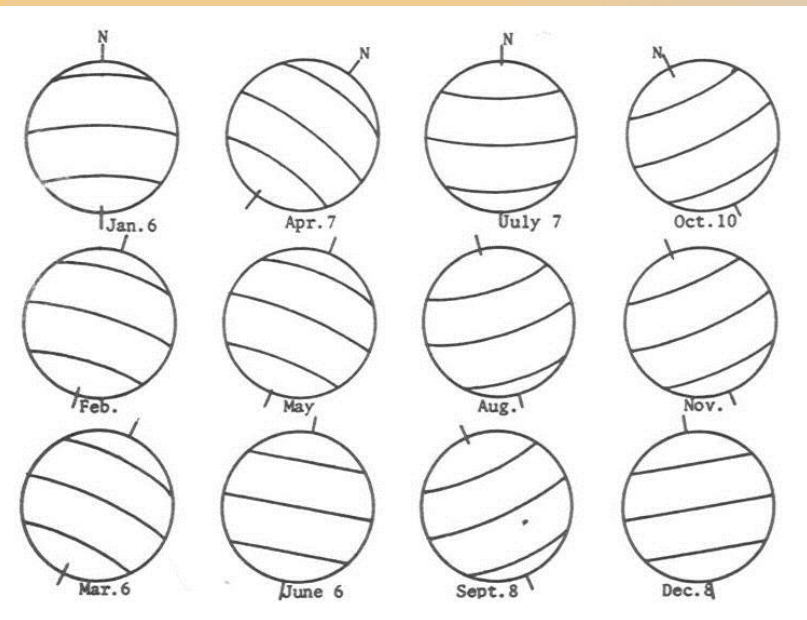


LASCO
C3





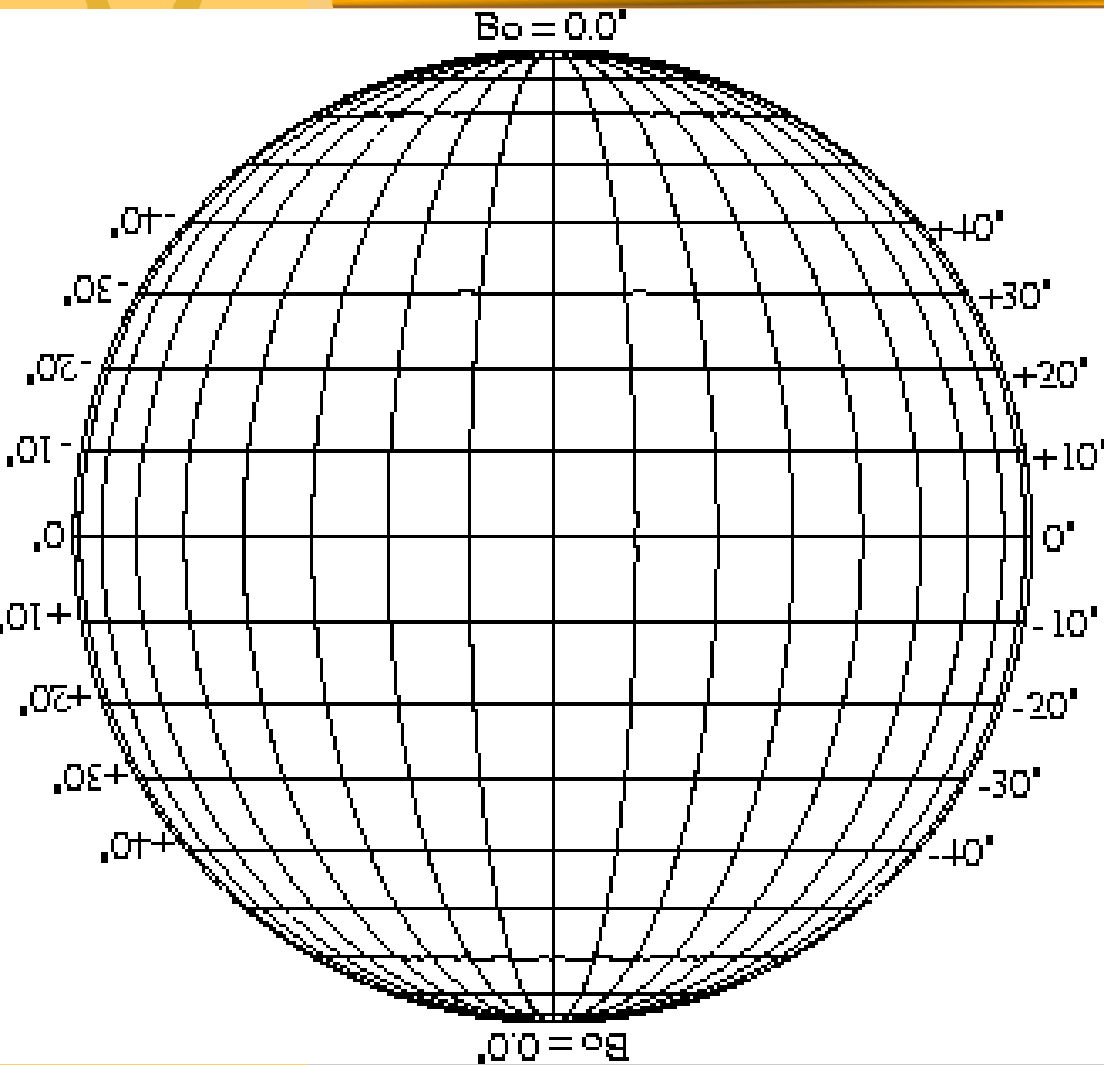
Solar Axis Tilt



- ★ The sun's axis appears to tilt throughout the year
- ★ Sun's tilt - $7^{\circ} 15'$
- ★ Earth's tilt - $23^{\circ} 27'$
- ★ Axis appears vertical:
 - Jan 6 – North back
 - Jul 7 – South back



Heliographic Coordinates

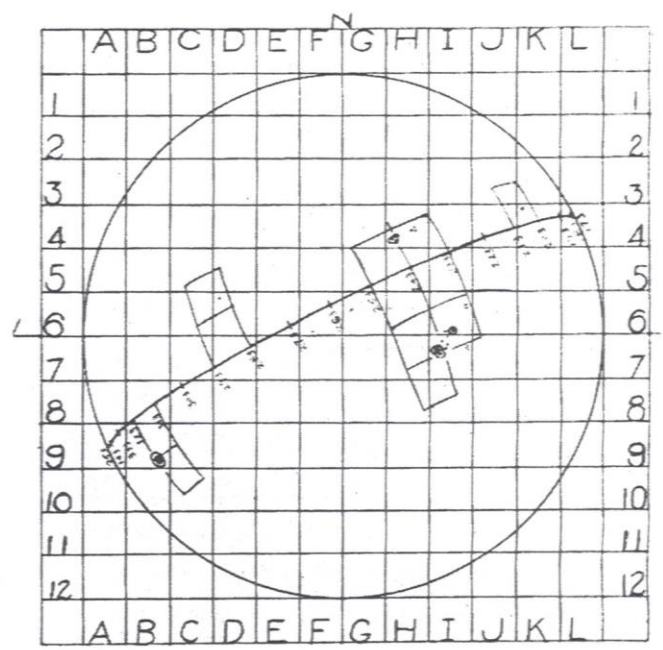


- ★ To be useful, sunspot records must use a common frame of reference based on solar latitude and apparent longitude
- ★ Amateur Astronomers often use Astronomical League drawing form
- ★ Professional astronomers use the Stonyhurst disk shown at right



Convert Visual to Actual Coordinates

DATE: 3-25-75 U.T. 1730 SUNSPOT NO 67 SEEING: G:2



LOC	NO	CLASS	LOC	NO	CLASS	NOTES
B8	1	H	K4	1	A	
D6	1	A				
H4	6	C				
K87	8	D				

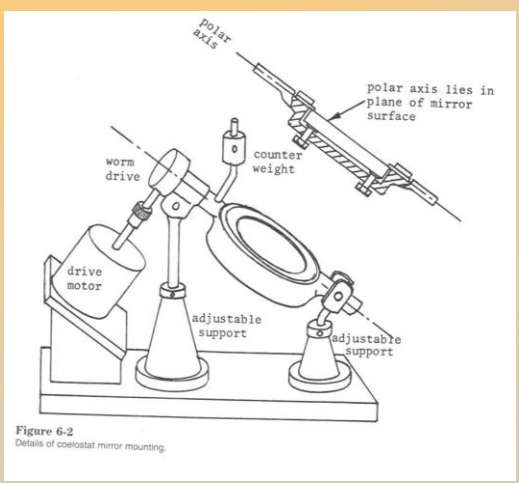
SUMMARY: N - 3 - 8
 S - 2 - 9
 5 - 17 = 67

- ★ The interaction of the sun's and Earth's axis tilt make placement difficult
- ★ Stonyhurst disks are used for projection scopes for easier recording
- ★ The solar emepheris is then consulted and the tilt is corrected to provide accurate location

Figure 4-8



Types of Amateur Solar Scopes



Celeostat
is a
motorized
reflective
telescope

Direct view
or pin-hole
projection
system

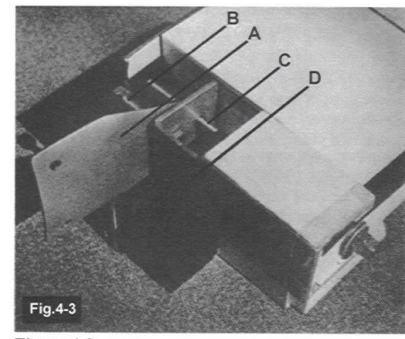


Figure 4-3



**Filtered
standard
telescope** –
many filter
types
available

**Solar
Dobsonian**
telescope –
using 1-way
mirror and
uncoated
mirror





Internet Links



Missions & Observatories

- ★ NASA Solar and Heliospheric Observatory (SOHO) Satellite <http://sohowww.nascom.nasa.gov/>
- ★ NASA Transition Region and Coronal Explorer (TRACE) Satellite <http://vestige.lmsal.com/TRACE/>
- ★ ESA/NASA Yohkoh Satellite <http://www.lmsal.com/YPOP/>
- ★ Big Bear Solar Observatory <http://www.bbso.njit.edu/>
- ★ Mees Observatory <http://www.solar.ifa.hawaii.edu/mees.html>

Education Sites

- ★ NASA Space Weather <http://www.spaceweather.com>
- ★ NASA Science web <http://science.nasa.gov/> <http://www.spacescience.com/>
- ★ NASA Solar Flare Theory <http://hesperia.gsfc.nasa.gov/sftheory/>
- ★ NASA Marshall Solar Physics <http://science.nasa.gov/ssl/PAD/solar/>
- ★ Thursday's Classroom <http://www.thursdaysclassroom.com>

Solar Observing Organizations

- ★ Association of Lunar & Planetary Observers (ALPO) – <http://www.lpl.arizona.edu/~rhill/alpo/solar.html>
- ★ Astronomical League Sunspotter's Club <http://www.astroleague.org/al/obsclubs/sunspot/sunsptcl.html>
- ★ British Astronomical Association http://ourworld.compuserve.com/homepages/M_Beaales/
- ★ American Association of Variable Star Observers, solar <http://www.aavso.org/solar/>
- ★ Yahoo Solar Astronomy site list http://dir.yahoo.com/Science/Astronomy/Solar_System/Sun/