

Reading: Chapter 14, 15

Astro 150 Fall 2020 Lecture 8 page 1

Exam 1: **Wednesday, Sept. 16 - in recitation** - review and sample posted

We will use the Respondus Lockdown Browser - be sure to download and try it out beforehand

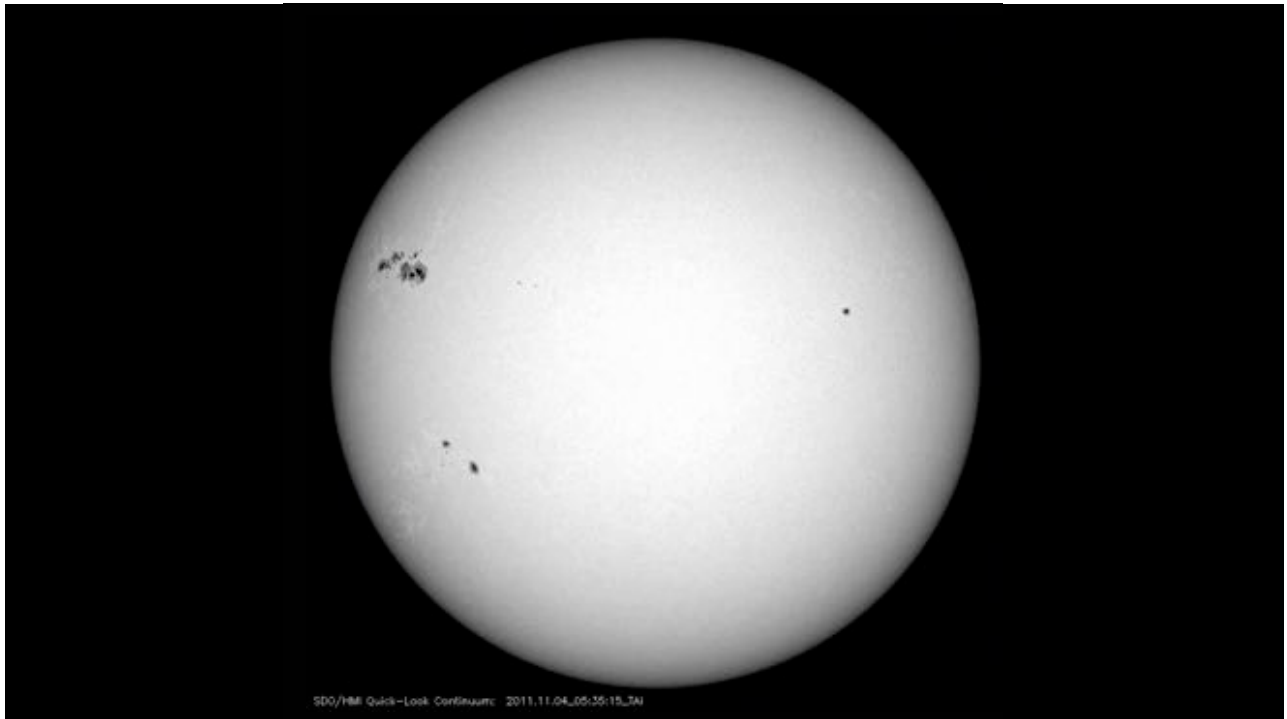
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### Last time: **What to do with those photons**

- instrumentation - squeezing info out of all photons
- getting around (or above) the atmosphere is critical
- astronomy from space provides access to all wavelengths

### Today: **Our Sun - a star, up close and personal**

- our local star, the Sun, is the touchstone for all of stellar astronomy
- what we see at and above the surface of the Sun tells us about how its energy eventually gets out into space
- The Sun is a dynamic powerhouse of light, magnetism, and turbulence.



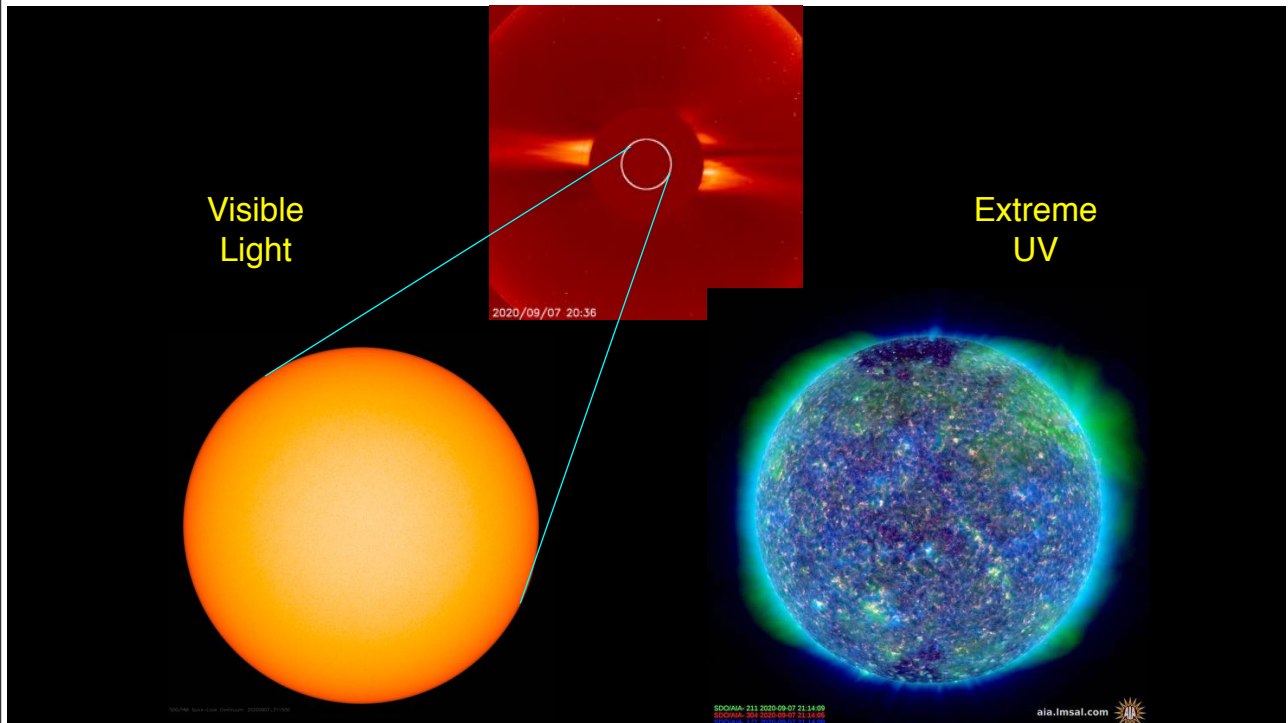
# The Vital Statistics of the Sun

<u>Distance:</u>	1.5×10 <sup>8</sup> km	Kepler's 3rd law
<u>Mass:</u>	2×10 <sup>33</sup> grams	Kepler's 3rd law
<u>Radius:</u>	7×10 <sup>5</sup> km	angular size & distance
<u>Luminosity:</u>	4×10 <sup>33</sup> erg/s	solar constant & distance
<u>Temperature:</u>	5800K (10,000° F)	Thermal Balance
<u>Composition:</u>		spectroscopy

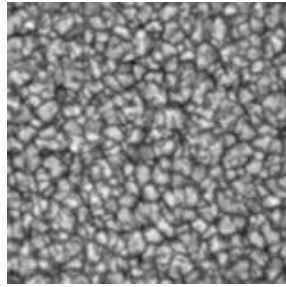
<b>Hydrogen</b>	<b>73.4%</b>	<b>by mass</b>
<b>Helium</b>	<b>24.8%</b>	“ “
Oxygen	0.8%	“ “
Carbon	0.4%	“ “
<i>everything else</i>	<b>0.6%</b>	“ “

i.e. Silver ~ 0.00000066% (still, that's 5×10<sup>20</sup> tons of silver in the Sun!)

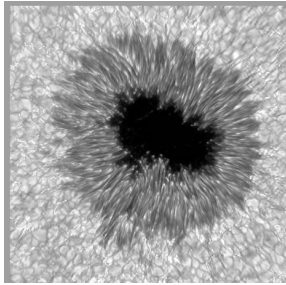
**1868:** Lockyer & Jansen find spectral lines in Sun never seen on Earth  
 → Helium proposed as a new element  
**1891:** Helium finally discovered on Earth



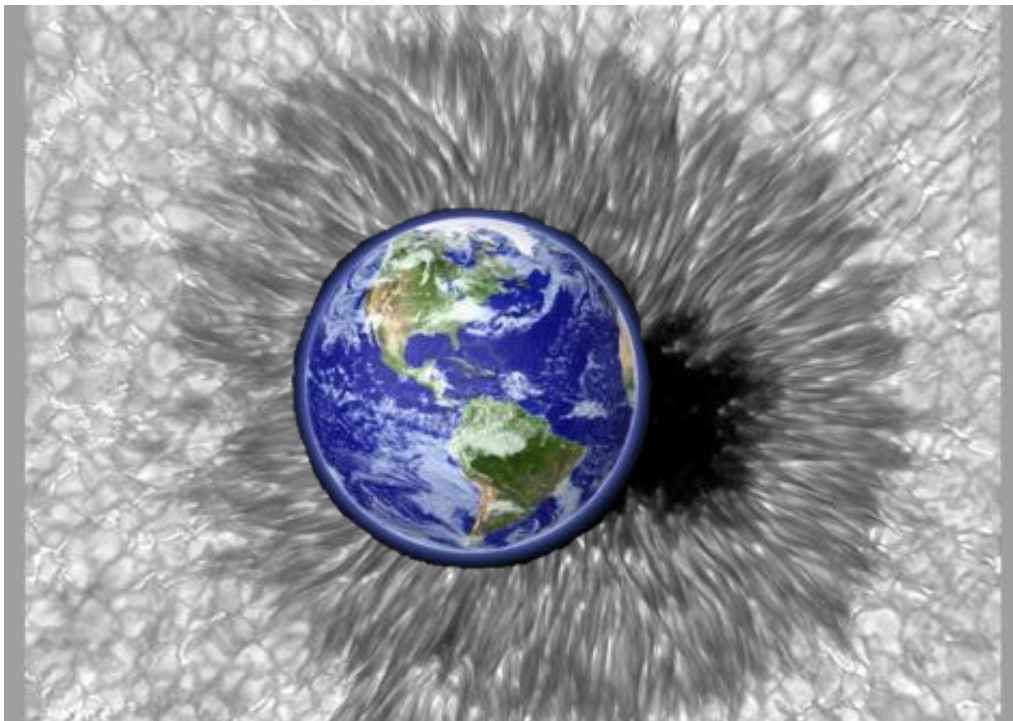
## The 'surface' of the Sun: the Photosphere

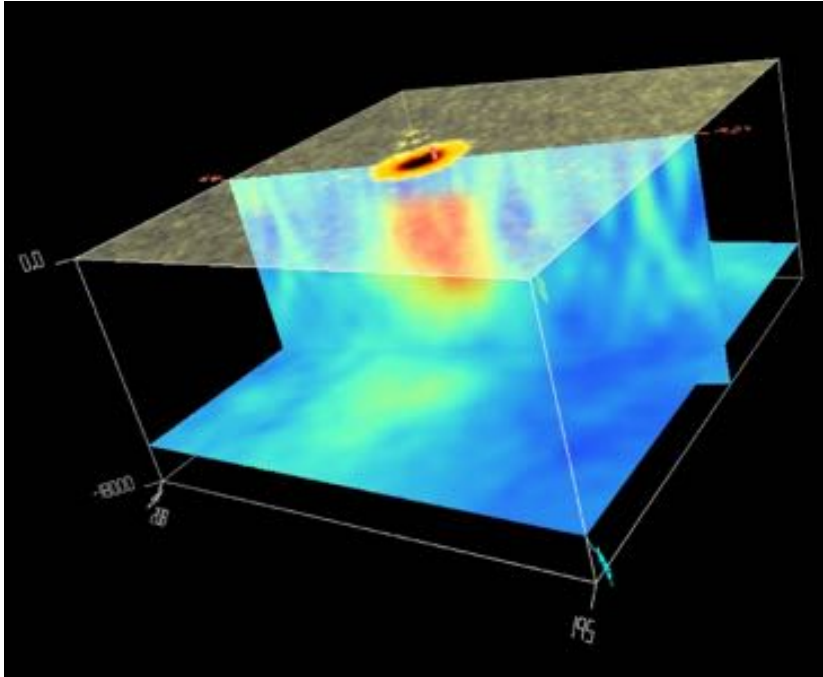


- $T \sim 5800\text{K}$
- **Granulation**
  - cells of rising gases ( $\sim 1000$  km across)
  - give mottled appearance to photosphere



- **Sunspots**
  - relatively cooler than photosphere ( $T \sim 4500\text{K}$ )
  - site of strong magnetic fields

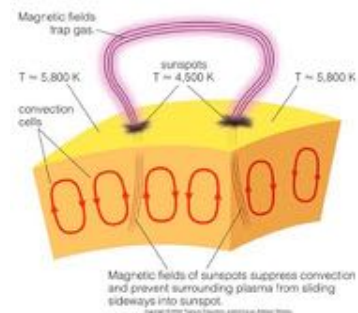
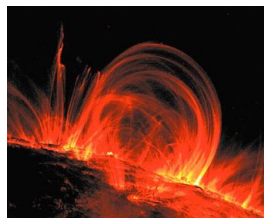


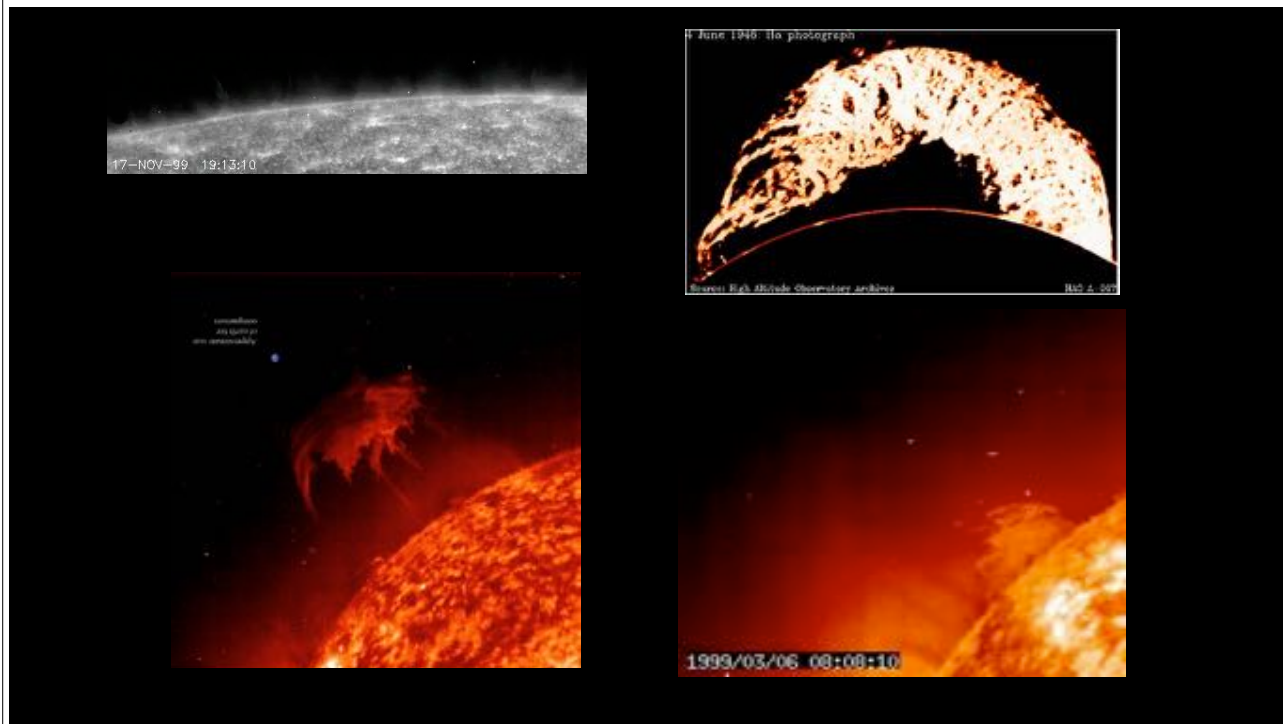


SOHO satellite image of a sunspot at and below the solar photosphere (using helioseismology)

## The Chromosphere

- cooler (and hotter) layer above photosphere
- dominated by (red) light of hydrogen emission
- **Prominences**
  - material suspended above photosphere
- **Flares**
  - giant eruptions





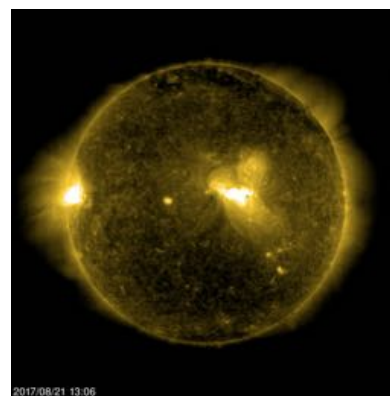
## The Solar Corona

Astro 150 Fall 2020 Lecture 8 page 10

- rarefied outer solar atmosphere
  - visible during eclipses or from space
- strange emission lines
  - identified as highly ionized heavy elements
  - $T \sim 2,000,000\text{K}$

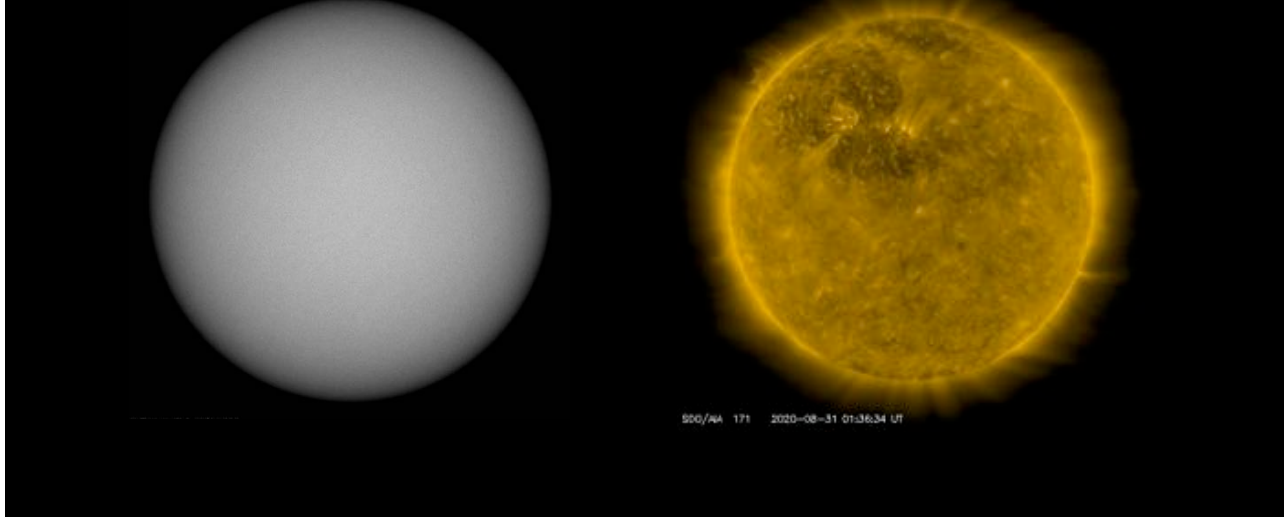


Optical image (eclipse)



Extreme UV (space)

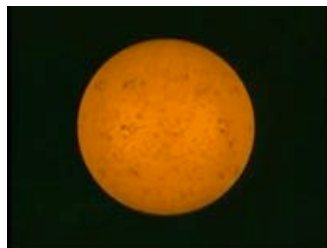
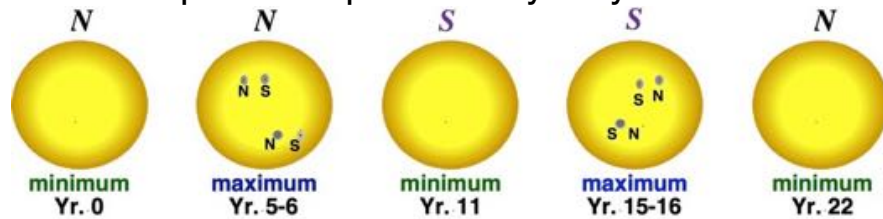
# The Sun this week



## The Solar Cycle

Astro 150 Fall 2020 Lecture 8 page 12

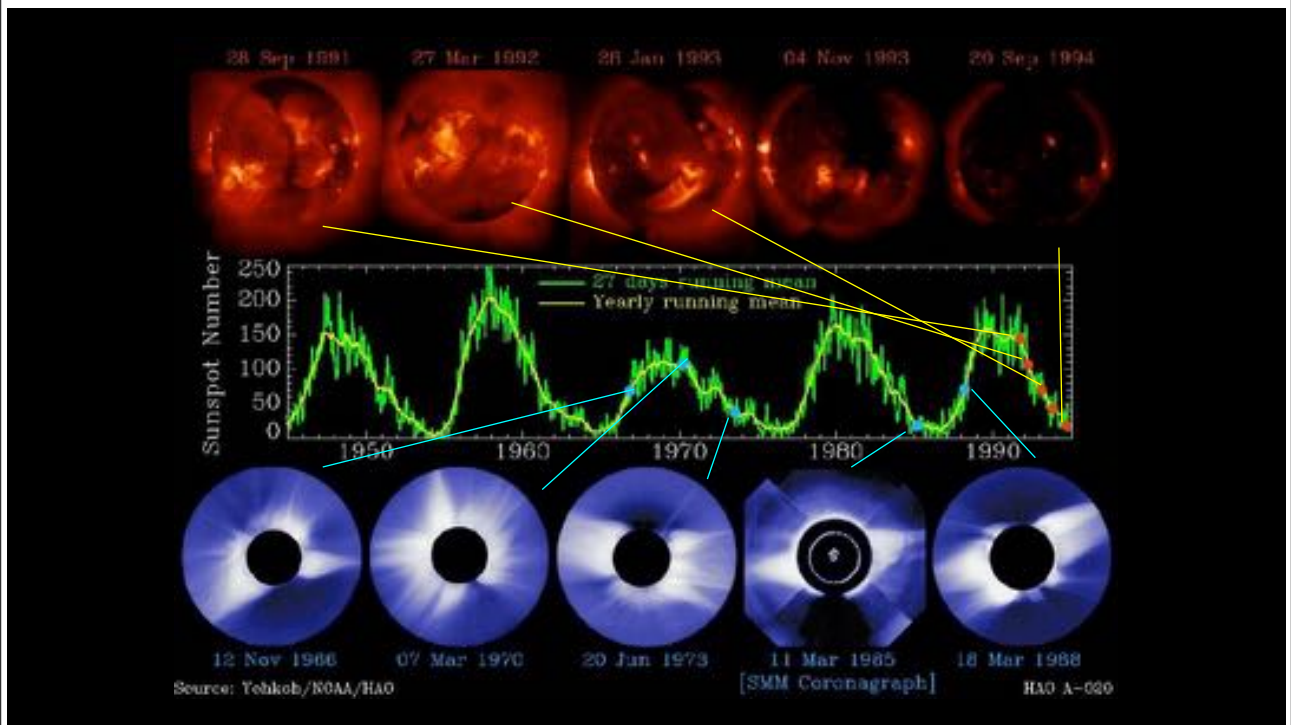
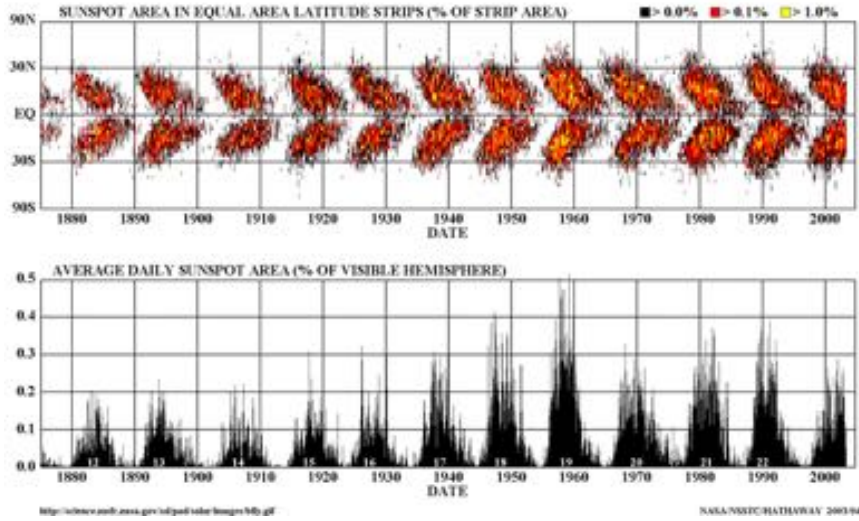
- number of spots changes over 11 year cycle
- magnetic polarity (N/S) of spots flips every 11 years
- —> whole pattern repeats every 22 years



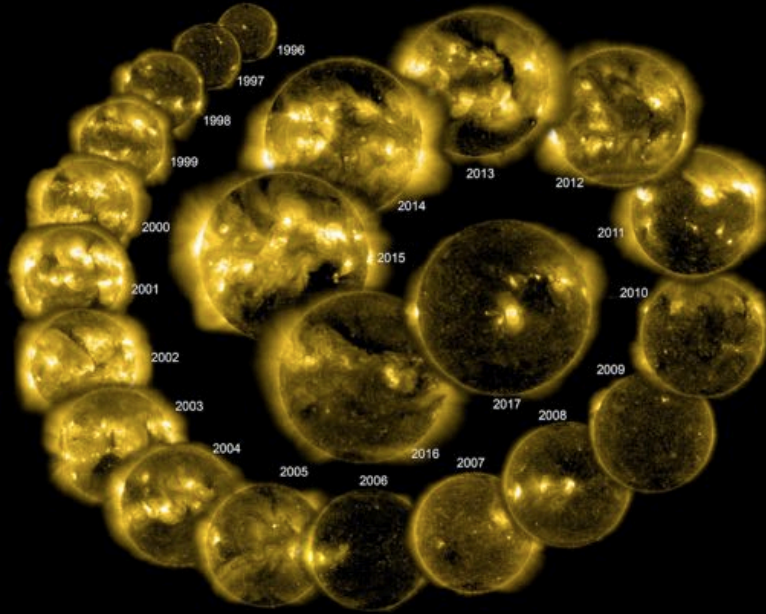


# The Butterfly Diagram

DAILY SUNSPOT AREA AVERAGED OVER INDIVIDUAL SOLAR ROTATIONS

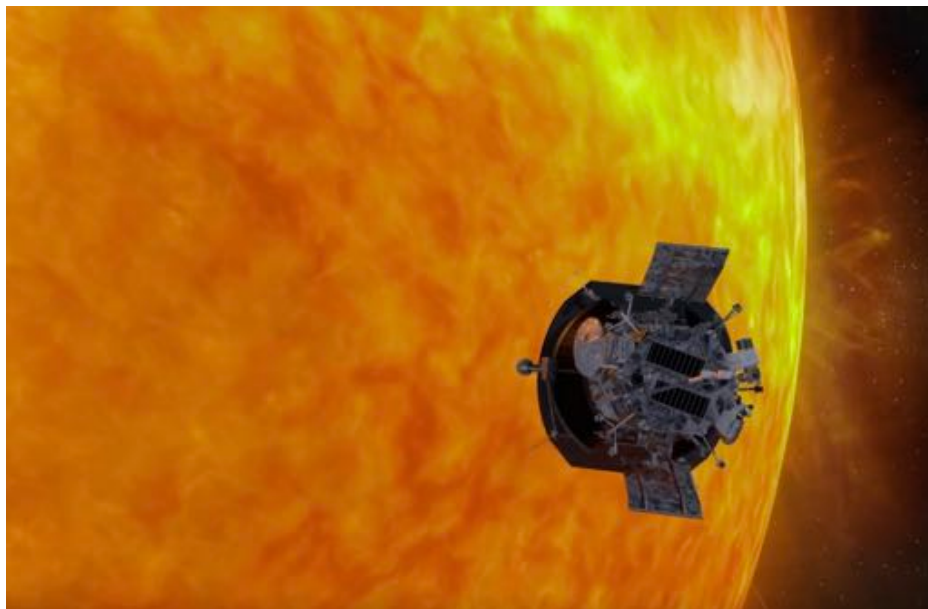


## 22 years of the Sun from SOHO



Astro 150 Fall 2020 Lecture 8 page 16

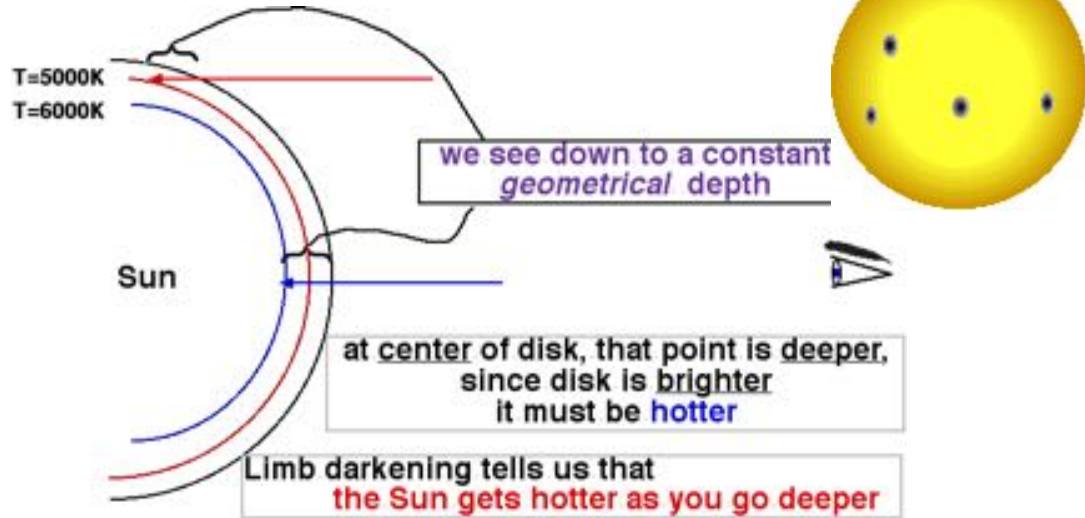
## Parker Solar Probe





# Limb Darkening:

a view below the surface of the Sun



inside the sun

## The Inside of the Sun:

- What keeps the Sun shining?
- What keeps the Sun from collapsing?
  - Mechanical Structure
    - balance between gravity and gas pressure
  - Thermal Structure
    - production, flow, and escape of radiant energy
  - Energy Source