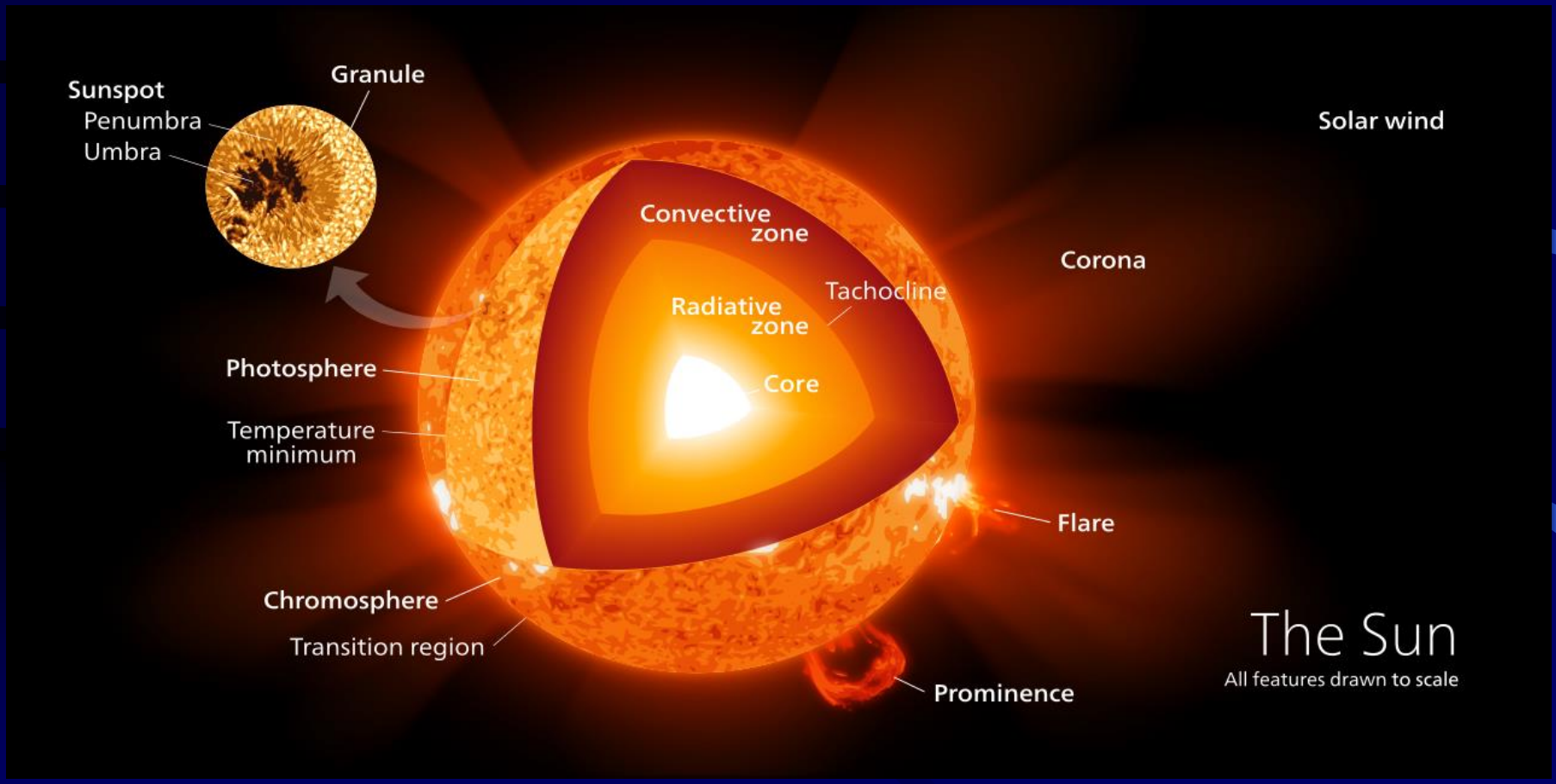
The Sun & Modern Physics

Focus on the Sun's outward appearance



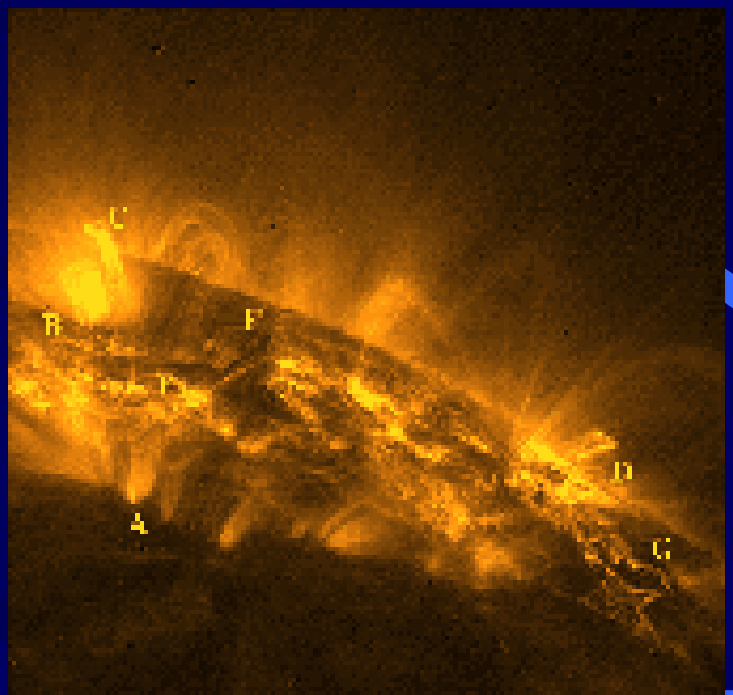
The outer layers of the sun

- Photosphere
  - Most of the light we see comes from the photosphere: dense ➔ blackbody radiation
- Chromosphere
  - Above the photosphere, about 4000 km deep
  - Pinkish glow
  - 10,000 thinner than photosphere

  ➔ emission spectrum, red Hα line
- Corona
  - Outermost layer
  - looks like a crown during eclipses
  - Very hot, very dilute

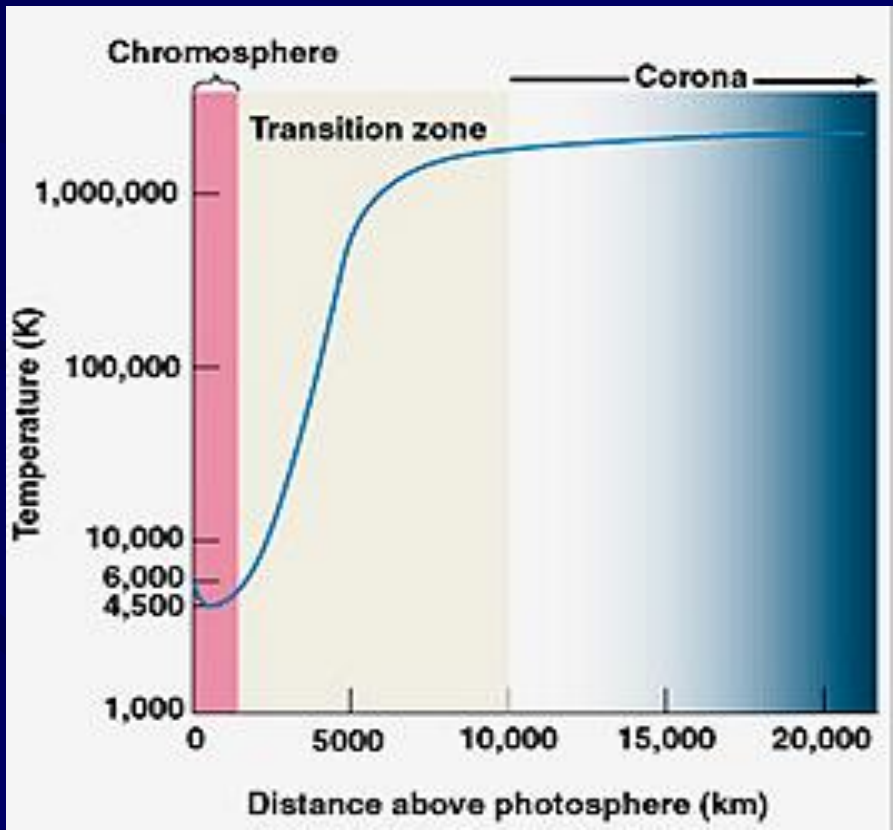
Chromosphere

- Above the photosphere
- Gas too thin to glow brightly, but visible during a solar eclipse
  - Characteristic pinkish color is due to emmision line of hydrogen
- Solar storms erupt in the chromosphere



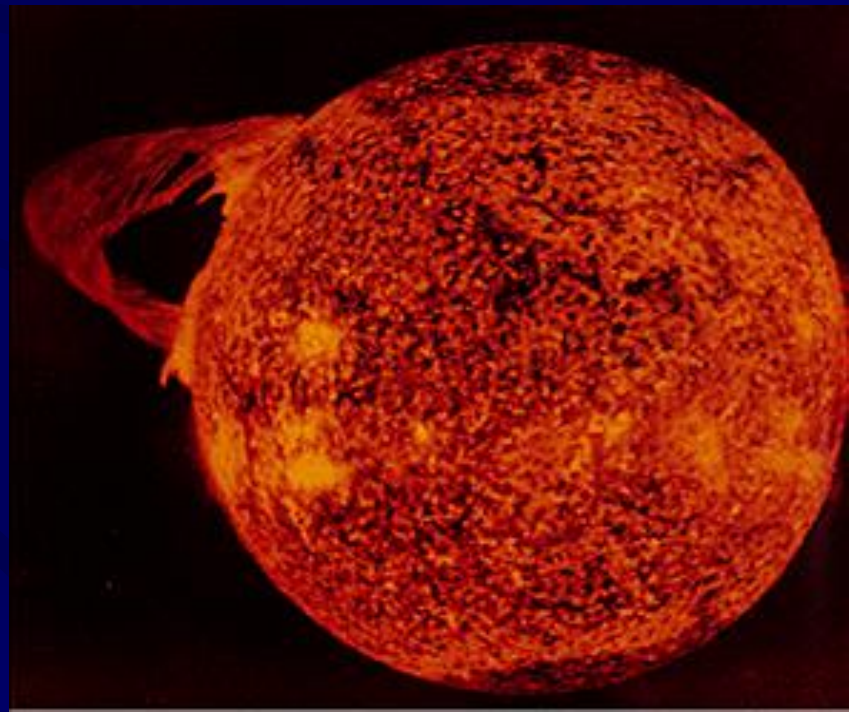
Solar Corona

- Thin, hot gas above the chromosphere
- High temperature produces elements that have lost some electrons
  - Emission in X-ray portion of spectrum
- Cause of high temperatures in the corona is unknown



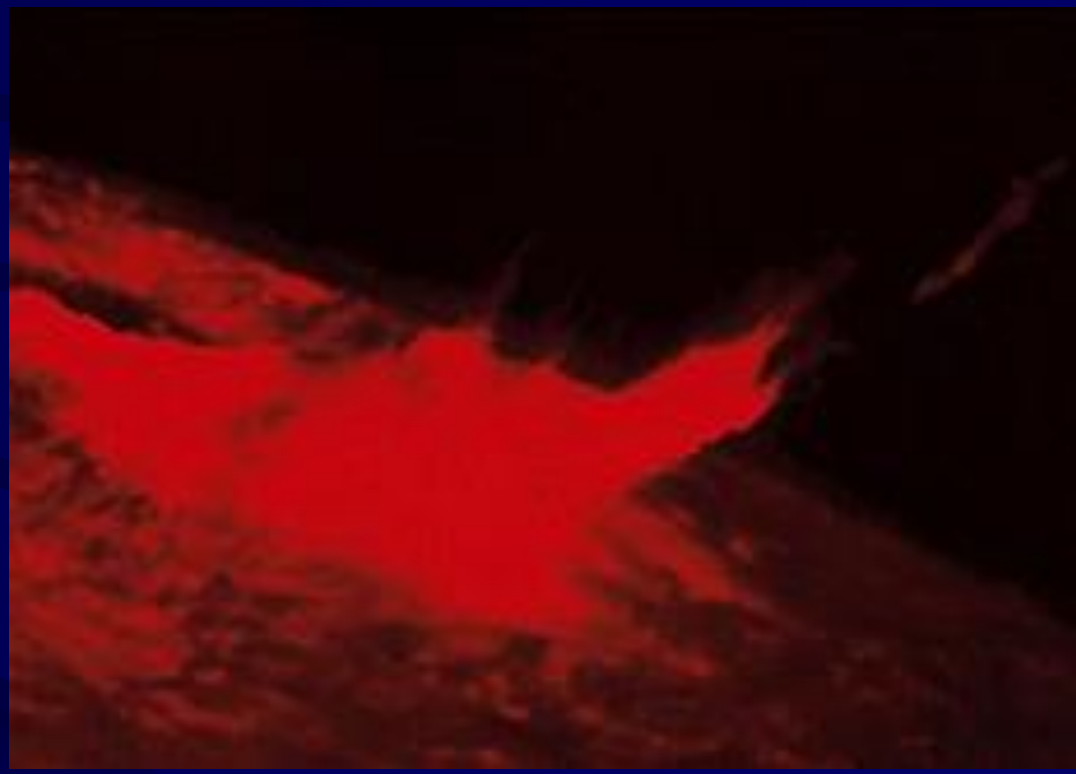
Prominences

- Loops or sheets of gas
- May last for hours to weeks; can be much larger than Earth
- Cause is unknown



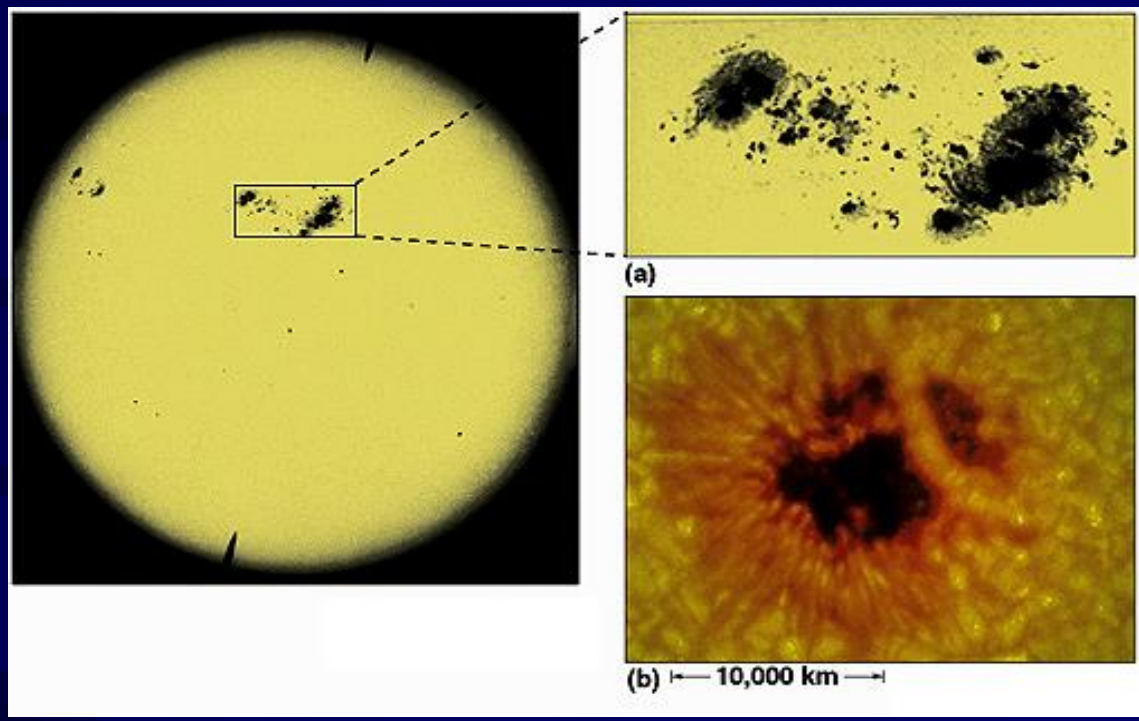
Solar Flares

- Like prominences, but so energetic that material is ejected from the Sun
- Temperatures up to 100 million K
- Flares and prominences are more common near sunspot maxima

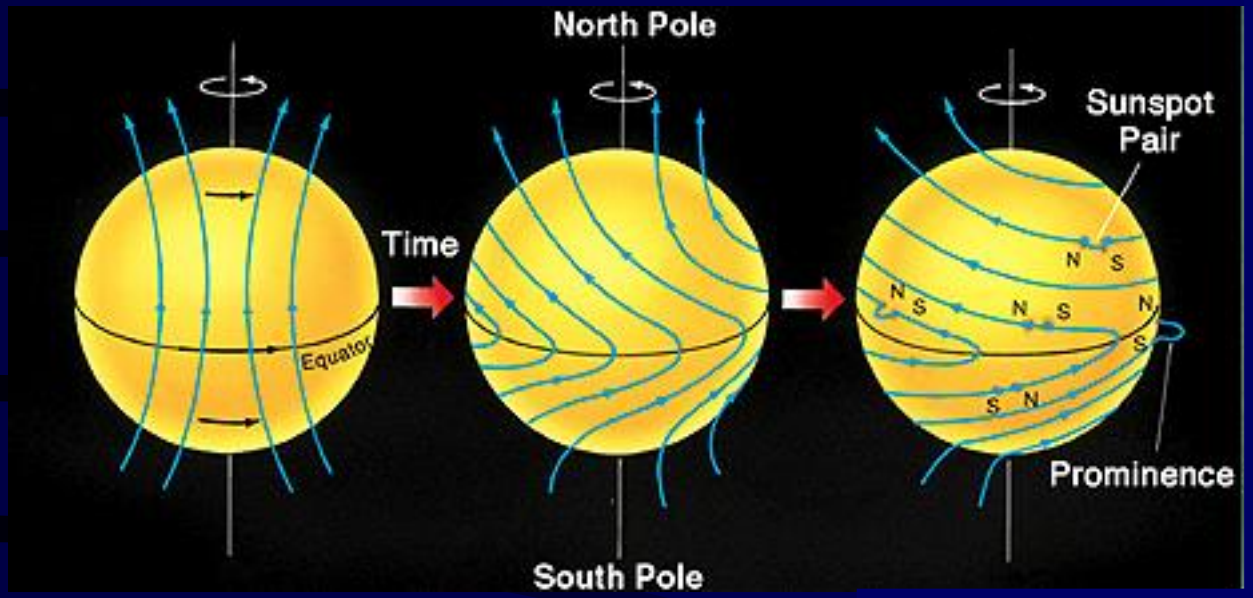


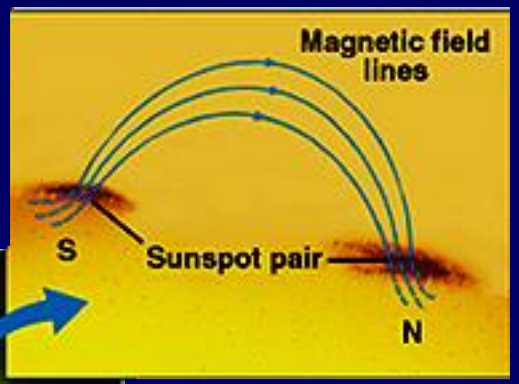
Sunspots

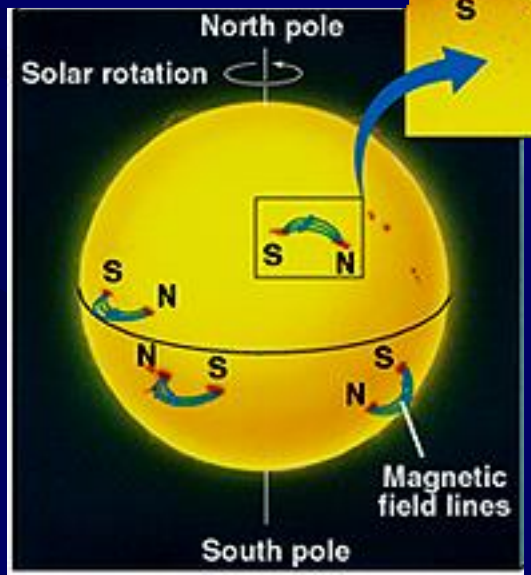
- Dark, cooler regions of photosphere first observed by Galileo
- About the size of the Earth
- Usually occur in pairs



Sunspots and Magnetism



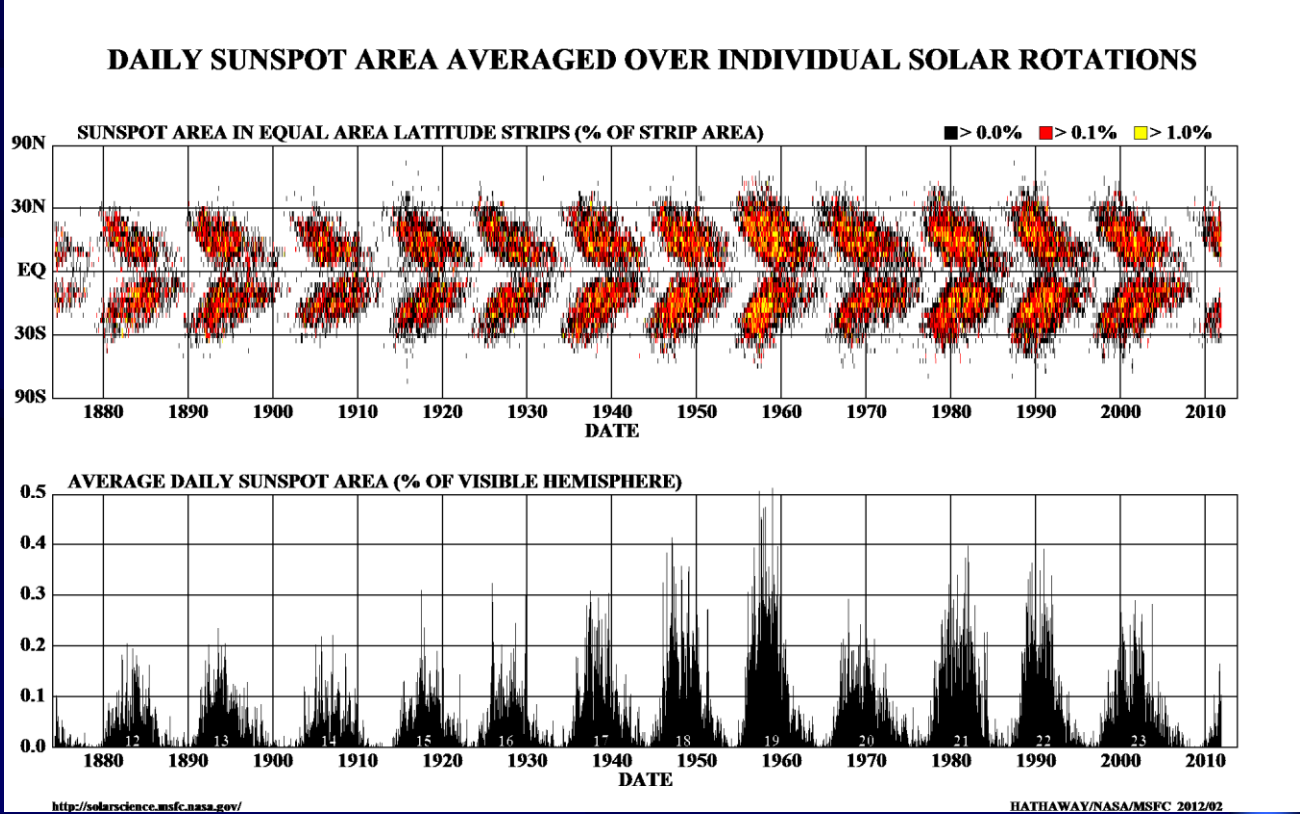




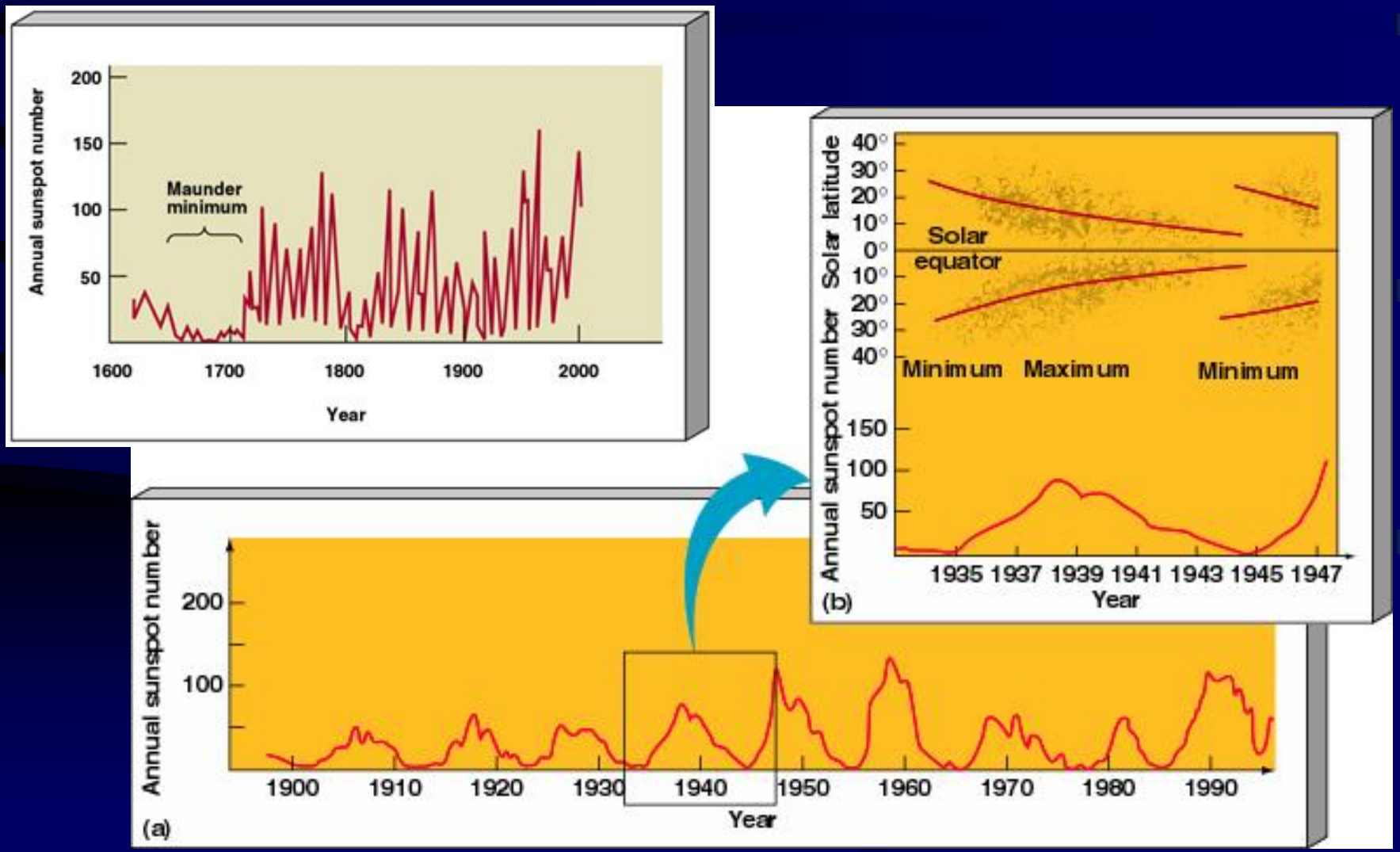
- Magnetic field lines are stretched by the Sun's rotation
- Pairs may be caused by kinks in the magnetic field (Babcock model)

Sunspot Cycle

- Schwabe (1843): number of sunspots fluctuates with a maximum about every 11 years: solar maxima & minima occur
- Magnetic field of the sun reverses every 11 years → 22 year cycle
- Formation location varies over the course of the cycle



The Solar Cycle



Understanding Stars

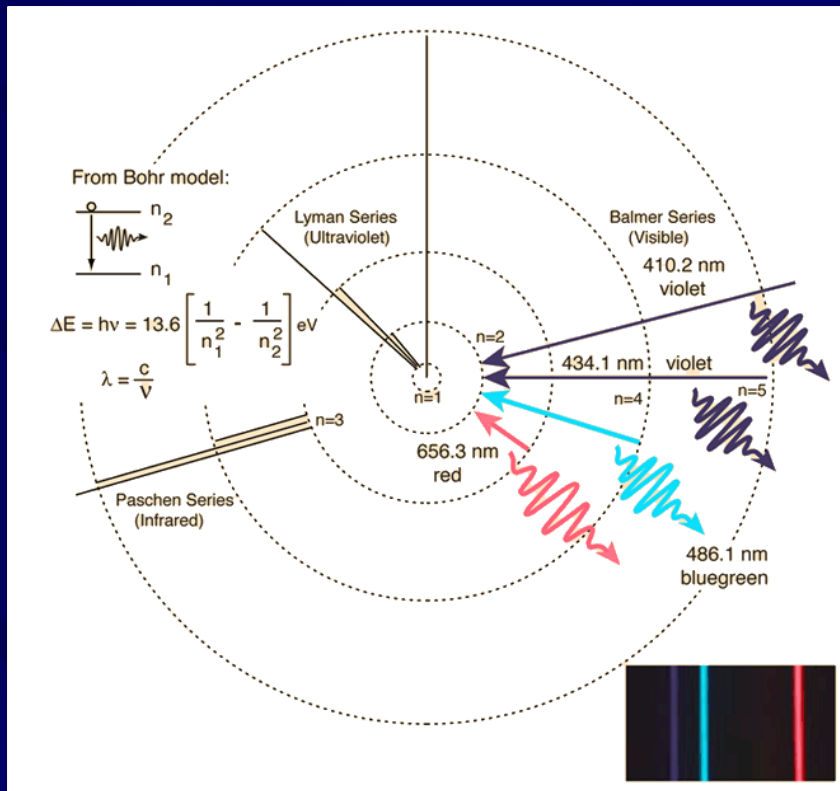
- "Understanding" in the scientific sense means coming up with a model that describes how they "work":
  - Collecting data (Identify the stars)
  - Analyzing data (Classify the stars)
  - Building a theory (Explain the classes and their differences)
  - Making predictions
  - Testing predictions by more observations

A bit of Modern Physics to understand Stars

- The classical laws of physics are only an approximation at slow speed and macroscopic objects!
- Theory of Relativity (1905/1915)
  - Need to use when speeds are comparable to speed of light: c
- Quantum Mechanics (1900/1913/1925)
  - Need to use when objects are atomic size, when observing the object will change the object: h

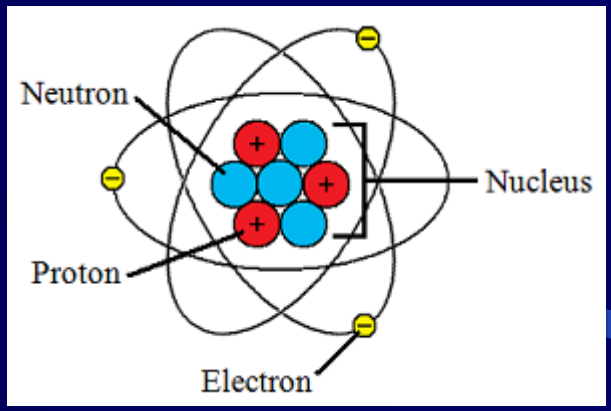
Consequences (Super-short Version)

- $E = mc^2$, we can transform mass into energy and vice versa. Mass is not conserved, energy is → Particle accelerators
- The emission/absorption spectra of gases are explained by quantum mechanics
  - Only certain atomic energy levels are allowed! Jumping from one to the other, electrons give/gobble up energy (emission/absorption)



Elements are not Elementary: the Building Blocks of Nature

Group →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period ↓																		
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La	* 72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	* 104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
				* 58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
				* 90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	



- Atoms are made from protons, neutrons, electrons
- Chemical elements are named by the number A of protons in their nucleus
- Atoms with same A but different number of neutrons N are called isotopes or nuclides