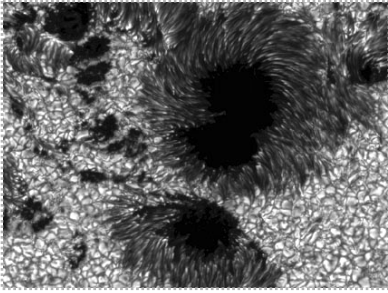


ASTR 1120: Stars & Galaxies



Prof. Juri Toomre TA: Ben Brown
Lecture 12 Mon 7 Feb 05
zeus.colorado.edu/astr1120-toomre

Topics for Today

- *Solar magnetic dynamo*: how the Sun builds (and destroys) its *magnetic fields*
- Start reading *Chap 16, Properties of Stars*
- Next class: What can we measure in other stars, how we classify them (O,B,A....)
- *Observatory Night # 3* today Mon 7 Feb (7pm, 8pm, 9pm -- by sign-up)
- *Review Sheet* still available for in-class *Midterm Exam 1* this *Fri 11 Feb* (review session this Wed 11 Feb, 7pm, here)

Reading Clicker Q **B.**

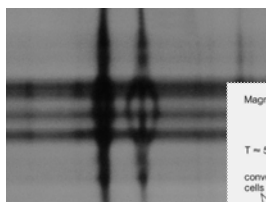
- *Helioseismology* uses sound waves bouncing within the Sun to study flows and structures deep inside. How are they detected and measured?
- A. By listening very carefully, since 5-minute periods hard to hear otherwise
- B. By observing Doppler shifts of spectral line emitted by solar surface moving up and down
- C. By seeing how solar prominences wiggle
- D. By using the Zeeman effect
- E. By its effect on 11-year solar activity cycle

Clicker – Doppler shifts? **A.**

- Star moving away from us at 0.01 the speed of light emits a spectral line with a wavelength of 600 nanometers (nm). What is the observed wavelength of that line?
- A. 606 nm
- B. 600.6 nm
- C. 594 nm
- D. 596.4 nm
- E. 600 nm

$$\Delta\lambda / \lambda = v/c$$

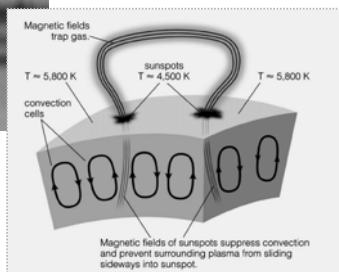
Sunspots show “Zeeman splitting”



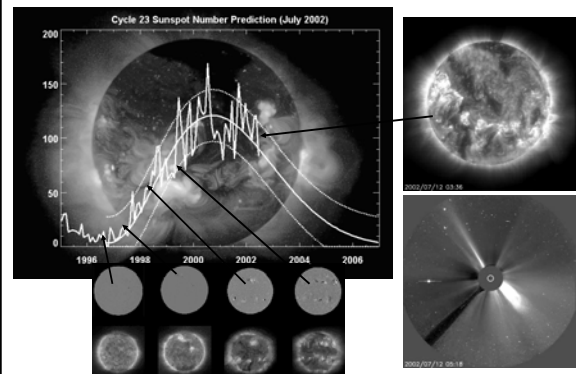
wavelength →

B demo

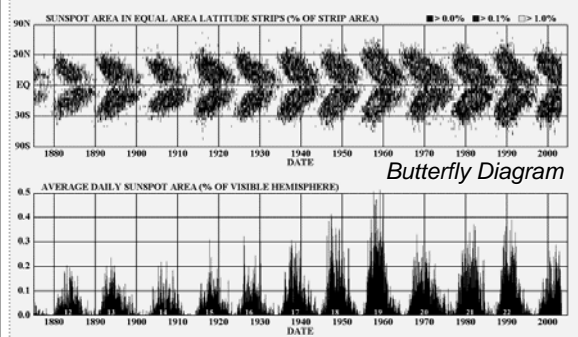
1000+ Gauss magnetic fields in sunspots



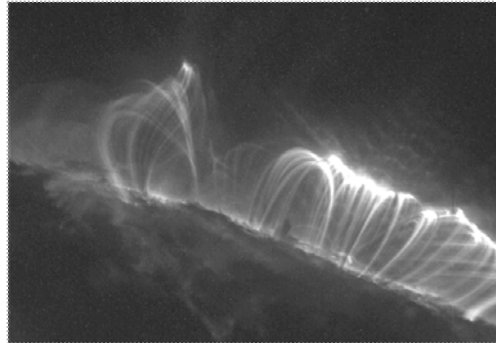
Magnetic Solar Cycle 23



11-year Cycles of Solar Activity

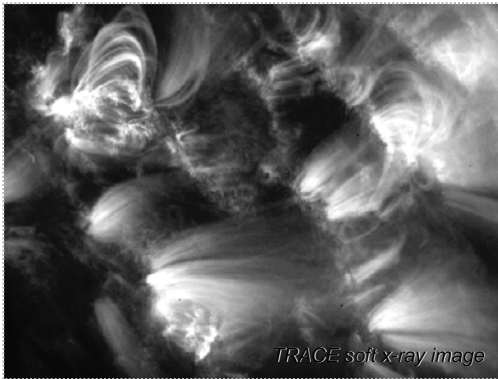


But what really is a “magnetic field”?

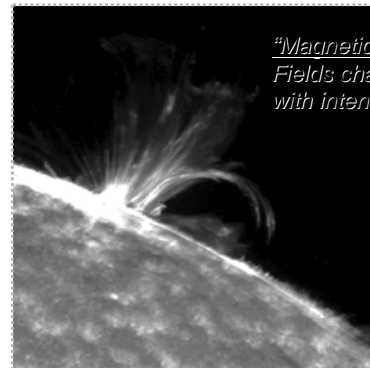


TRACE soft x-ray image: Arcade of magnetic loops on solar limb

Complex “magnetic carpet” in low corona



Flares involve huge releases of energy



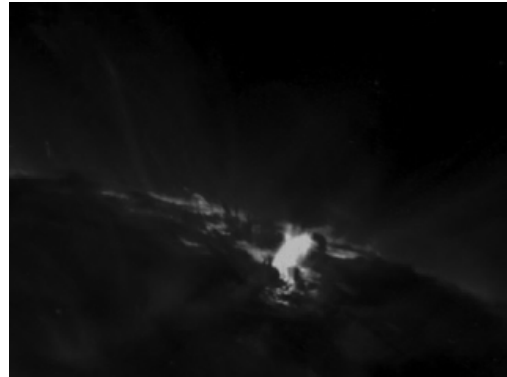
“Magnetic reconnection”:
Fields change drastically,
with intense electric currents

Many other stars
flare -- with Sun you
can see its details!

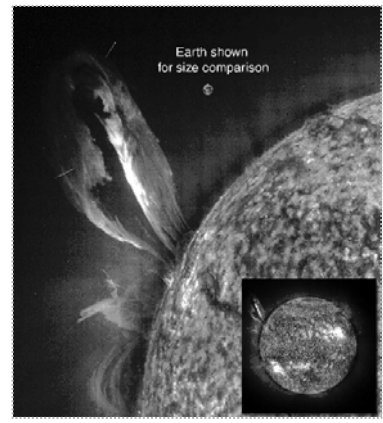
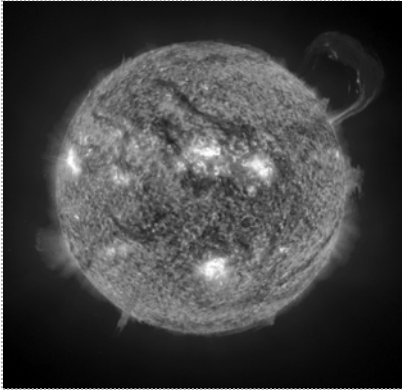
Major flare develops, loops light up



Another major flare (X-class)



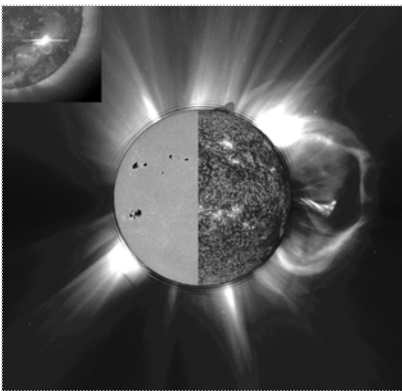
Huge prominence is big magnetic loop



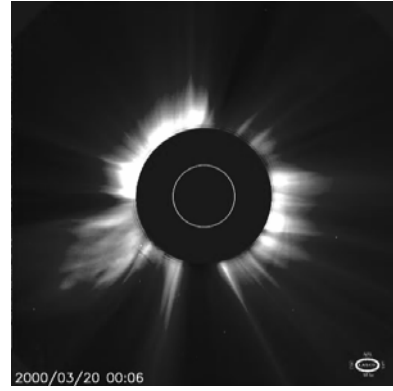
Huge Solar Ejecta

Coronal Mass Ejection (CME) outbound

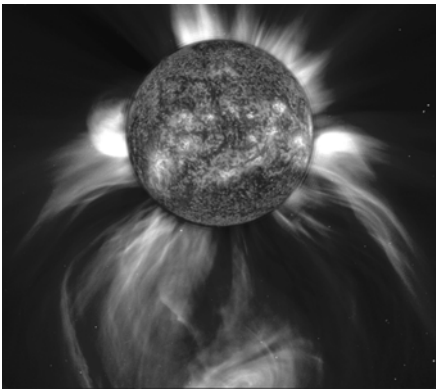
Many Faces of the Sun: Composite



Coronal Mass Ejections (CMEs)



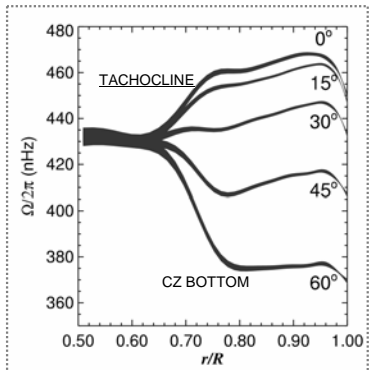
Combo: CME and UV disk



Clicker – Solar Maximum ? **D.**

- *What observed features characterize the Sun at “solar maximum” ?*
- A. Sun becomes much brighter
- B. Sun emits light of longer wavelengths
- C. Sun rotates faster at the equator
- D. Many sunspots are visible on surface
- E. All of the above

So how are solar magnetic fields built?

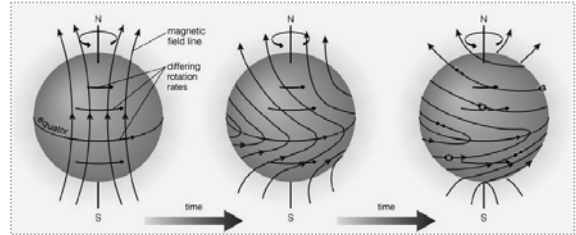


TWO MAGNETIC DYNAMOS:

Global magnetic fields built in TACHOCLINE

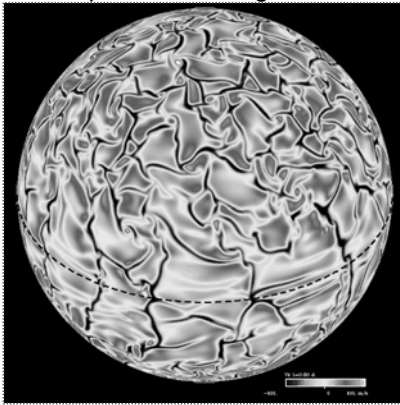
Small-scale fields built in near-surface shear zone

How differential rotation can stretch and change global magnetic fields



True, but only one element in story...

Computer Modelling of Solar Convection

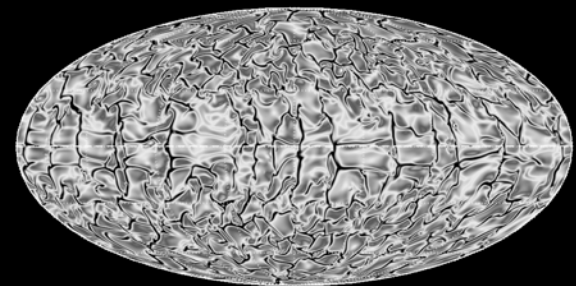


RADIAL VELOCITY NEAR TOP OF LAYER

Large-scale convection "drives the differential rotation"

Case E
Brun, Miesch & Toomre

Global View of Velocities in Simulations



Different Patterns Near Equator and Near Poles

Theoretical Solar Cycle

