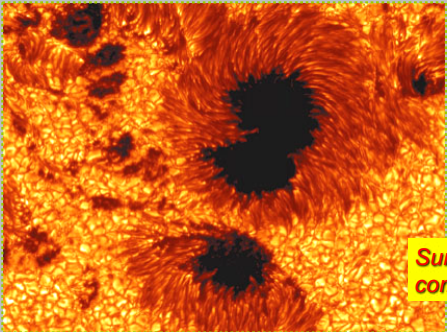


ASTR 1040: Stars & Galaxies



Sunspot complex

Prof. Juri Toomre TAs: Piyush Agrawal, Connor Bice
Lecture 8 Thur 9 Feb 2017
zeus.colorado.edu/astr1040-toomre

Topics for Today and Tues

- Energy transport by *convection* (granulation)
- Rich solar magnetism and its cycles
- Sunspots and the “butterfly diagram”
- How to measure Sun’s magnetic fields
- *Helioseismology*: acoustic waves excited by convection to probe interior
- Start reading *Chap 15: Surveying the Stars*
- New *Homework #4* passed out; *Review Set for Mid-Term Exam 1* (next Thurs in class)
- *Observ tonight* Recitation Notes on D2L

Solar Thermostat

- Why doesn’t the Sun go into a runaway reaction?
Fusion rate is VERY sensitive to temperature,
→ tight feedback loop

CRUCIAL

A. If energy generation (fusion rate) speeds up:

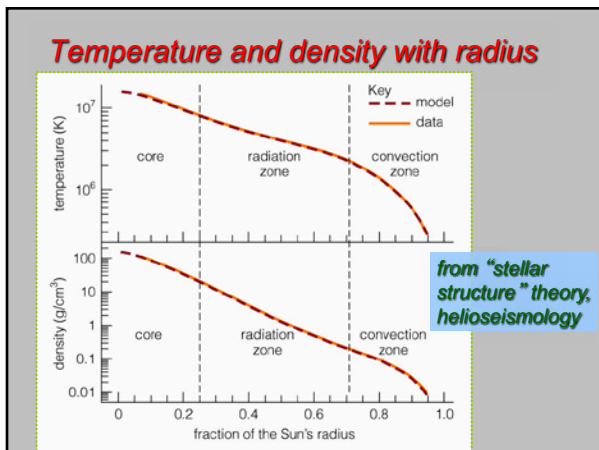
1. Pressure in core will increase, lifting the gas against gravity (core expands)
2. Gravitational energy is created from thermal energy → the gas cools
3. **Energy generation (fusion rate) slows down**

More on solar thermostat

B. However, if energy generation drops:

1. Core pressure drops
2. Solar core starts to shrink
3. Temperature rises
4. **Fusion rates go up again**

- **Sun is remarkably stable**, only small (30%?) increase in fusion rate over billions of years

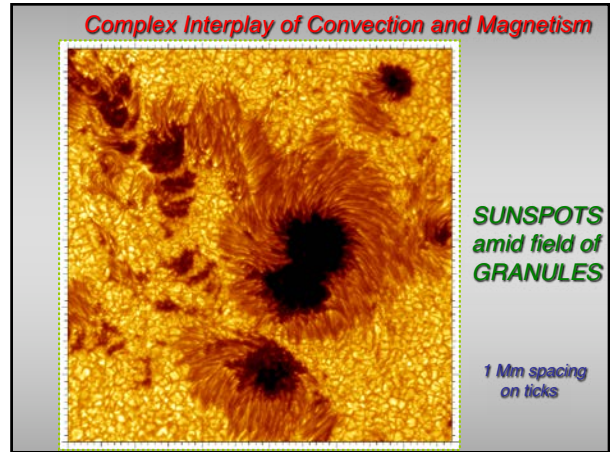
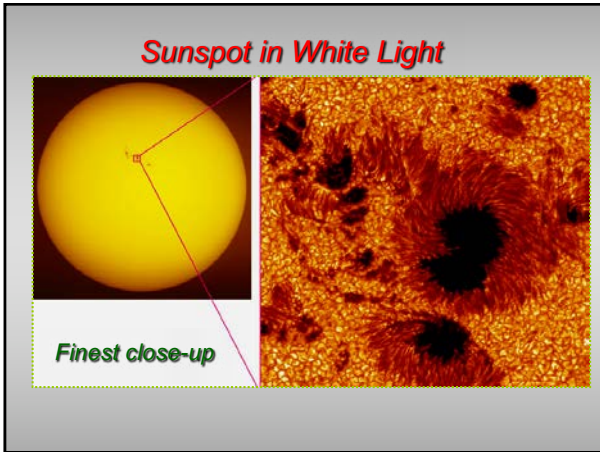
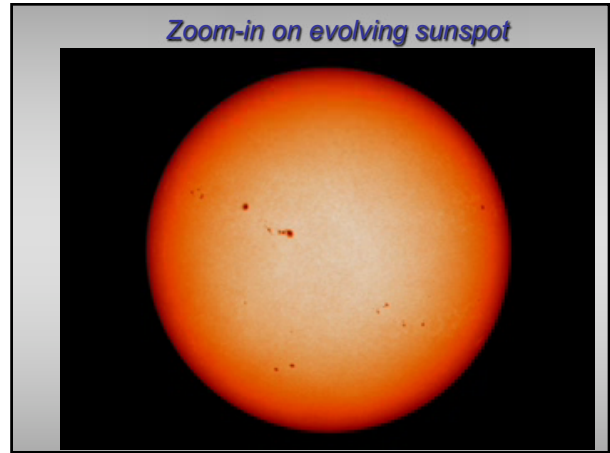
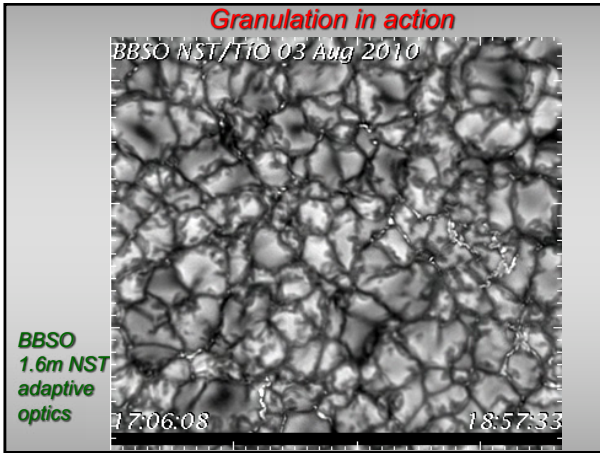
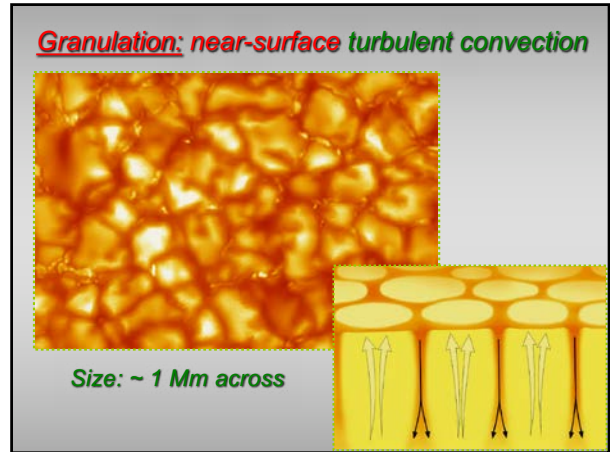
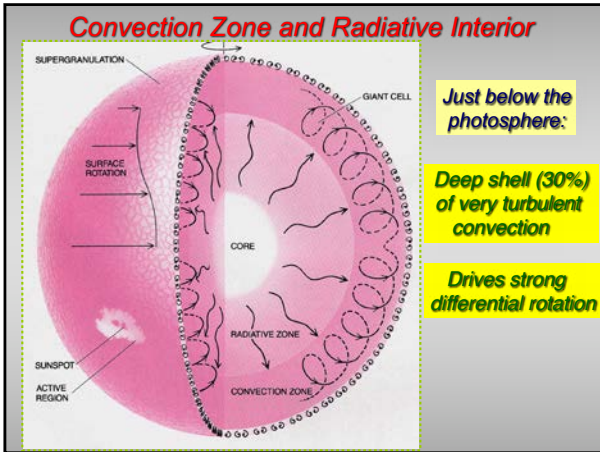


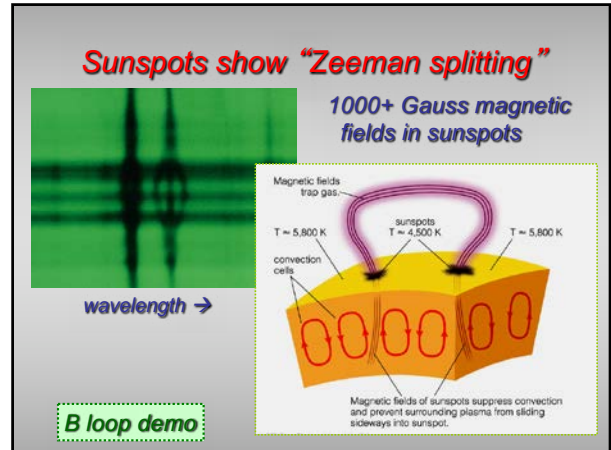
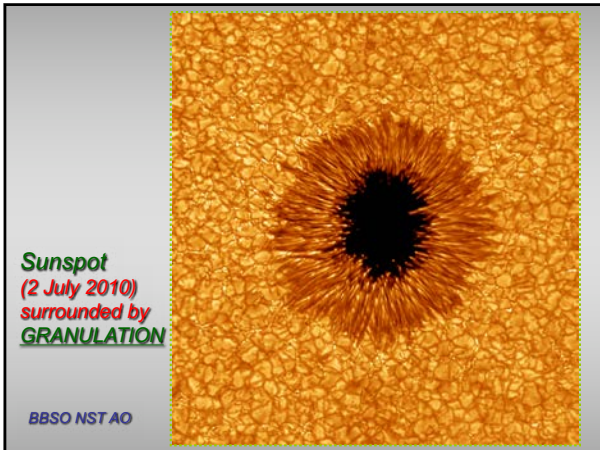
Clicker – Doppler shifts? A.

- 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

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





SOLAR MAGNETISM

SURFACE FEATURES

SUN : SURFACE FEATURES (S. GARRETT)

ROTATION : SEEN FROM MOTION OF SUNSPOTS, AND DAILY DRIFT

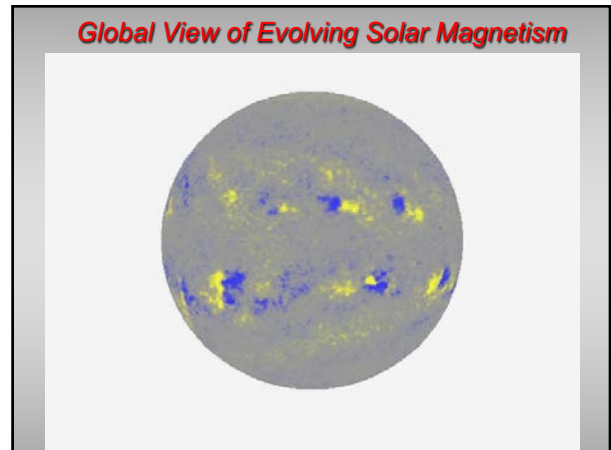
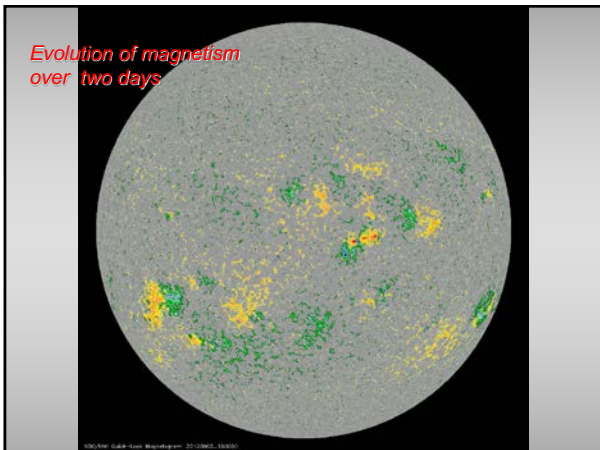
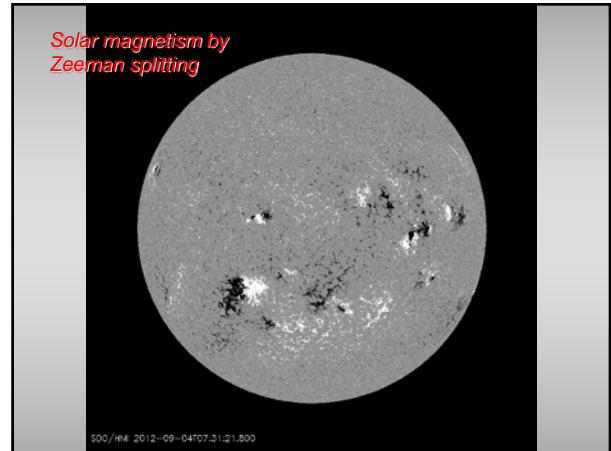
25 DAYS (EQUATOR)
28 DAYS (MID-LATITUDE)
33 DAYS (POLES)
SUN ROTATES "DIFFERENTIALLY"

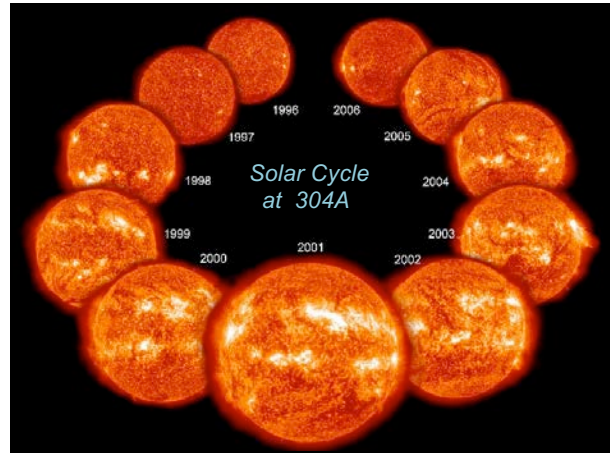
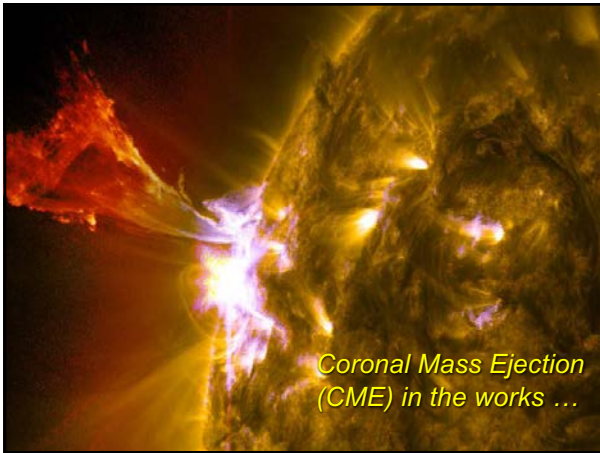
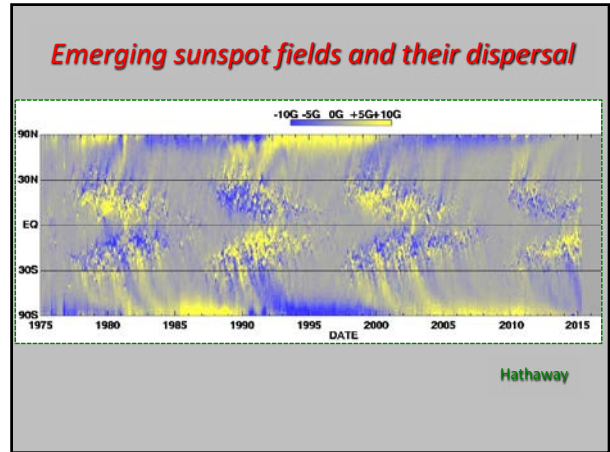
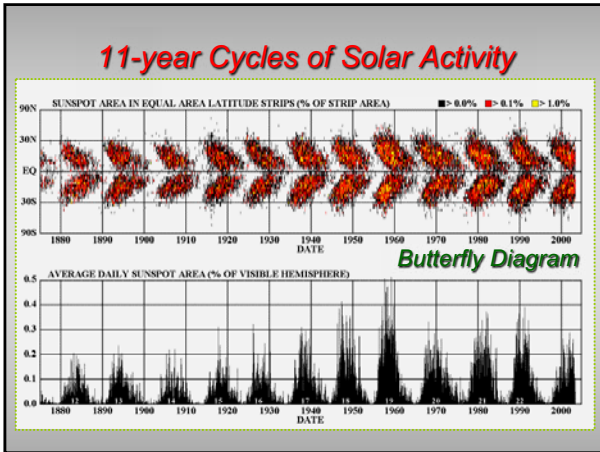
SUNSPOTS: COOL SPOTS (4000K), STRONGLY MAGNETIZED EXHIBIT 11-YEAR CYCLE OF "ACTIVITY"

FLARES: INTENSE MAGNETIC STORMS

PROMINENCES (FILAMENTS) : SEVERES OF GEE IN CORONA (ARCHES OF MAGNETIC FIELD) (LIKE GRACE) (LIKE GRACE)

ACTIVE REGIONS OR PLACES (BRIGHT BEACH!) : WIDE REGIONS OR PATCHES OF MODERATE MAGNETIC FIELDS (MAYBE WITH SUNSPOTS INSIDE) APPEAR BRIGHT IN HYDROGEN ALPHA (H α) LINE





Let us make some plasma!
Demo of TESLA COIL
(like all-electric sports car)

Powerful electric fields reach out