Today

- Solar dynamo models, effects of solar wind
- What can we measure in other stars?
- How do we begin to classify other stars? Why O, B, A … such a nutty scheme!

- Review Session given tonight (Wed 9 Feb) by Ben Brown, here in G1B20, 7pm-9pm
- Review Sheet still available for in-class Mid-term Exam 1 this Fri 11 Feb
- Homework #3 (graded), plus answer sheet, being returned today

Clicker – Energy is how “old”? E.

- Light radiated from Sun’s surface reaches us in about 8 minutes, but the energy of that light was released by fusion in the solar core about …
  - A. one year ago
  - B. ten years ago
  - C. a hundred years ago
  - D. a thousand years ago
  - E. a million years ago

Meanderings of outbound photons

P-P chain makes gamma-ray photons, which “random walk” outwards (getting absorbed, re-emitted), gradually cooling

REMINDER

Magnetic fields are built in convection zone

Convection Zone: ROTATING SHELL OF TURBULENT PLASMA

Differential Rotation and Magnetic Dynamo go HAND-IN-HAND

REMINDER

Computer Modelling of Solar Convection

Large-scale convection “drives the differential rotation”

REMINDER
Global View of Velocities in Simulations

Different Patterns Near Equator and Near Poles

Modelling Convection Close to Surface

THIN SHELL STUDIES OF SUPERGRANULATION AND NEAR-SURFACE SHEAR LAYER

Smaller scales of convection driven near the solar surface

DeRosa, Gilman & Toomre

Computer Model: Toroidal Magnetic Fields

Dynamo action by global-scale convection

Case M3
Brun et al

Radial Magnetic Fields in Computer Model

View during solar eclipse

Theoretical Solar Cycle

PHOTOSPHERE
CONVECTION ZONE
TACHOCLINE
RADIATIVE INTERIOR

EMERGING LOOP
ROTATION
LOCAL DYNAMO
GLOBAL DYNAMO
PUMPING

The Moon casts the Sun

Emerging Loop
Convection Zones
Tachocline
Radiative Interior

Global View of Velocities in Simulations

Modelling Convection Close to Surface

Computer Model: Toroidal Magnetic Fields

Radial Magnetic Fields in Computer Model

Theoretical Solar Cycle

View during solar eclipse
**Reading Clicker -- Solar Wind**

E. What are visible effects of the Earth being “bathed” in the wind of solar particles, especially when wind has strong hiccup?

- A. “Auroral lights” visible at night
- B. Electric power grids have problems
- C. Short-wave radio talk interrupted
- D. Satellites (and beepers) may get fried
- E. All of the above

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**Solar Wind and Earth’s Magnetosphere**

Earth’s Magnetic Field

**Solar Wind and Aurorae**

**Northern Lights**

(Aurora Borealis)

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**Now onward to measuring other stars:**

Chap 16 – PROPERTIES OF STARS

- Measuring stellar luminosities
- Measuring distances
- Measuring temperatures

**Often only seeing a point of light**

- Stars are so small compared to their distance that we almost never have the resolution to see their sizes and details directly — “point sources”
- We deduce everything by measuring the amount of light (brightness) at different wavelengths (color, spectra)
So what can we find out about other stars?

**APPARENT BRIGHTNESS**

**POSITION**

**SPECTRUM**

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**Most Basic Problem in Astronomy**

Star of given **APPARENT BRIGHTNESS** could be either

A. very luminous star far away
B. low luminosity star closer by

Need to know the **DISTANCE** to the star

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**Inverse Square Law of Brightness**

\[
\text{Apparent Brightness} \approx \frac{L_0}{(\text{distance})^2}
\]

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**Clicker – Dimming with distance ?**

- If you quadruple (x4) your distance to a light and look again, how much dimmer does it appear?
  - A. one-half as bright as originally
  - B. one-fourth as bright
  - C. one-eight as bright
  - D. one-sixteenth as bright
  - E. unchanged, since really same light

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**Stellar Luminosity**

- What we measure: **APPARENT BRIGHTNESS**
  - or how bright it appears to us here on Earth
- What we want to know: (absolute) **LUMINOSITY**
  - or how much energy is emitted (Joules/sec or watts)
- Need to know **DISTANCE** to the star

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**Parallax – to determine distance**

- Measure the apparent movement of stars over a year
- Movement is caused by Earth's movement around the Sun
- Closer objects will move more than farther objects
**Stellar Parallax:**
measuring nearby distances

**How Stellar Parallax Works**

1. **Your nose is the Sun**
2. **Your left eye is the Earth in January**
3. **Your right eye is the Earth in June**

Watch the apparent motion of your thumb against a distant reference point (repeat at arm’s length)

Which “move” more → closer or farther objects?

**Class self-demo of parallax**

**Best parallax measurer:**
Hipparcos satellite 1989-1993

- Space measurements not affected by atmosphere
- Measurement made many times until accurate to 0.001 arcsec (≈3300 light years)
- 100,000 stars mapped
- (2.5 million to slightly lesser accuracy)