**Topics for Today**

- “Kirchoff’s Laws” about emission and absorption features in spectra
- Doppler shift (both for sound waves and electromagnetic waves) – and “redshift”
- Telescopes and their instruments
- Why are big optical telescopes reflectors and not refractors? *(discussion on Thur, provide your answer on WebCT)*

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**Reading**

- Finish reading Chap 7 (Telescopes)
- Start reading Chap 15 (Our Star .. the Sun)
- Homework Set 1 due Thur, new one then
- You can get copy of all slides after class from course website

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**NATURE OF SPECTRA**

**Kirchoff’s laws**

- Emission
  - Continuum spectrum
  - Blackbody spectrum
- Absorption
  - Emission line spectrum
  - Absorption line spectrum

**CONTINUOUS SPECTRUM**

**BLACK-BODY SPECTRUM**

- Peak emission and total energy VARY with temperature
  - Planck’s radiation law: $E(\lambda, T) = \frac{2\pi\sigma T^4}{\lambda^5} \exp\left(\frac{hc}{\lambda kT}\right) - 1$
  - Stefan-Boltzmann law: $\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Spectra of Continuous Emission
(from us and stars)

15,000 K star
the Sun (6,000 K)
3,000 K star
3,10 K human

UP the temperature: FAR MORE emission peak at SHORTER wavelengths

In what ways is an electron orbiting the nucleus of an atom different from a planet orbiting the Sun?

- A. The central force is electromagnetic (+ and - charges attract), not gravity
- B. Not all orbits are allowed—only certain sizes (they are quantized)
- C. Because atomic orbits behave differently from “regular” orbits we call them orbitals
- D. An electron can jump or make a transition from one orbital to another
- E. All of the above

Doppler Effect: Trains and Light

Moving Light SOURCES

DOPPLER EFFECT

Applied to positions of spectral lines

Measuring the Line Shift

<table>
<thead>
<tr>
<th>Laboratory spectrum</th>
<th>Stationary</th>
<th>Moving Away (redshifted)</th>
<th>Away Faster</th>
<th>Moving Toward (blueshifted)</th>
<th>Toward Faster</th>
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<tbody>
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<td>Object 1</td>
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- Measure the Doppler effect from shifts in the wavelengths of spectral lines

How does Doppler shift tell us the ROTATION RATE of a star?

Doppler shifts from different portions of star broaden the spectral line
**Discussion of how do ROTATING STARS yield Doppler-broadened spectral emission lines**

**Clicker Q – EM Waves**

- From **shortest to longest wavelength**, what is the correct sequence of EM radiation?
  - A. gamma-rays, x-rays, UV, visible, IR, radio
  - B. gamma-rays, x-rays, visible, UV, IR, radio
  - C. IR, visible, UV, x-rays, gamma-rays, radio
  - D. radio, IR, visible, UV, x-rays, gamma-rays

**A. gamma-rays, x-rays, UV, visible, IR, radio**

**Electromagnetic Spectrum**

- Discussion of **CELL PHONE frequencies and wavelengths** and what is involved with them
  - 850 MHz 1850 MHz

\[ \text{wavelength} \times \text{frequency} = \text{speed of light} \]
Now On to Telescopes

VLA – Socorro, NM