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Today

- Announcements:
  - The average on Exam 1 was 35/40; outstanding.
  - HW#5 and HW#6 is due October 19th.
  - Exam extra credit is due by 8:00am Friday
- Electric Materials
- What is temperature?
- The life of the stars

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Special Announcement

- Tonight Oct. 11^{th} at 8:00pm PBS (channel 23) will air "Einstein's Big Idea"
- This NOVA film will trace the history of the men and women who developed the concepts of $E=mc^2$.

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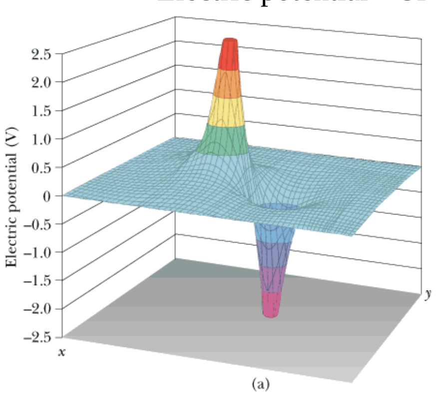
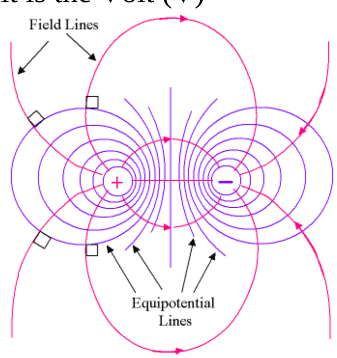
Electric Potential

Electric potential – SI unit is the Volt (V)



Serway, Physics for Scientists and Engineers, 5/e Figure 25.8a Harcourt, Inc.



$$E = -\frac{\Delta V}{\Delta x}$$

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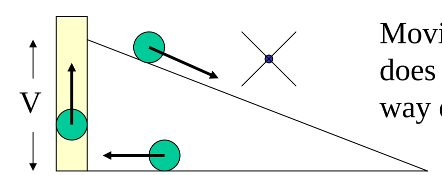
Flow of Charge - Current

- Current is the rate of flow of charge. SI units is Ampere = 1 Coulomb/second
- Batteries are like pumps that lift charge to a higher potential. The charge flows down the hill to the other side of the battery.

A battery is like a pump.



Moving Charge does work on the way down

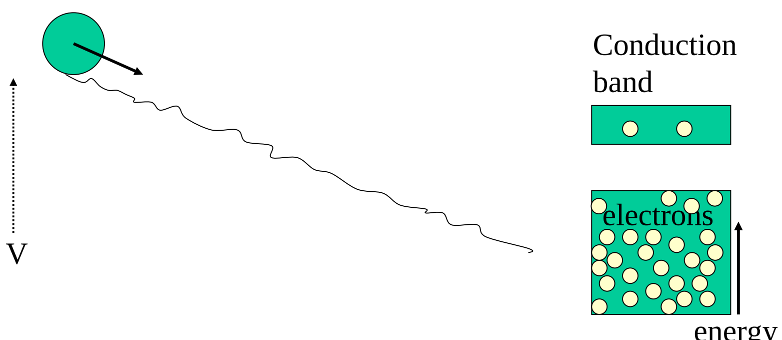
Ohm’s Law

- The amount of current that flows is related to the drop in potential (V) and the resistance to the flow of current, R (SI unit Ohms)
- Ohm’s Law: V=IR
- Analogy: The amount of water flowing in a river is related to the drop in elevation (volts) and the size of the river (resistance).

Types of materials

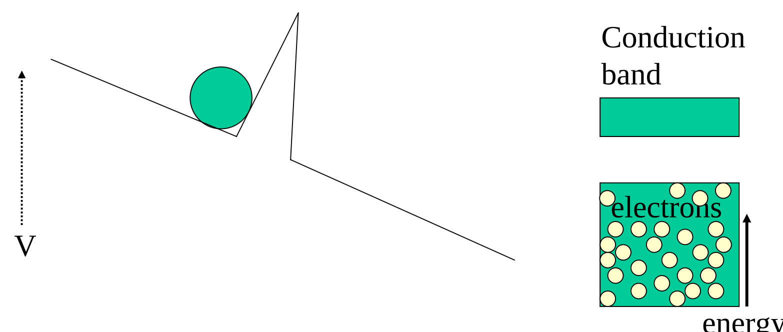
- **Conductor** – electrons in the conduction band; electrons relatively free to flow (copper, aluminum, gold, silver)
- **Insulator** – no electrons is the conduction band; electrons can not flow (wood, most rubber, most glass, most plastic)
- **Semiconductor** – at finite temperature, some electrons are in the conduction band (used in most electronics; silicon, germanium)
- **Superconductor** – at very low temperature electrons pair and can move freely without resistance (Niobium, Titanium, Lead)

Conductor



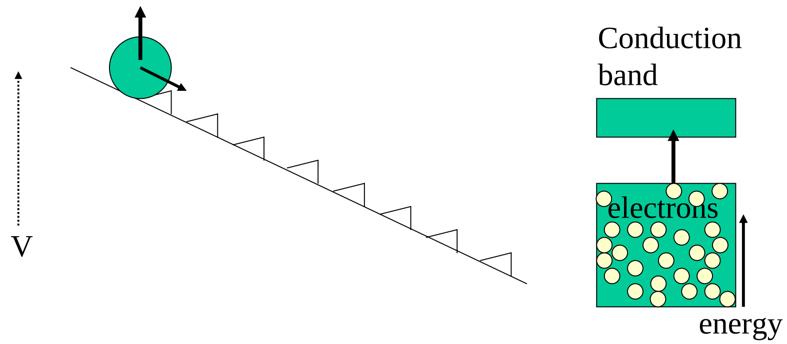
Electrons hit bumps, but are free to roll.

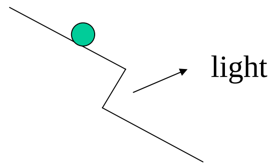
Insulator



Electrons are not free to roll.

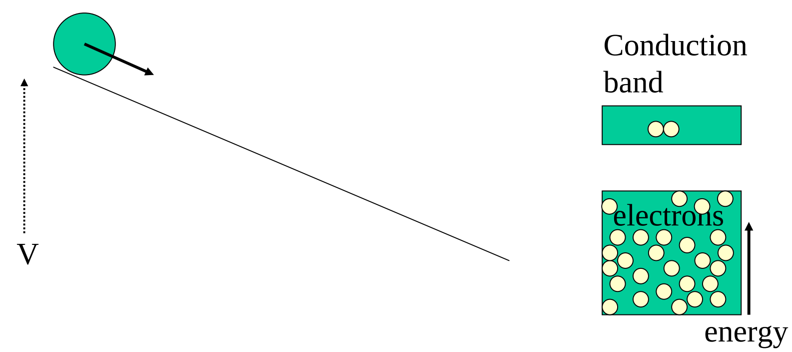
Semiconductor





LED – light emitting diode

Superconductor



No resistance to flow (also no use of energy)

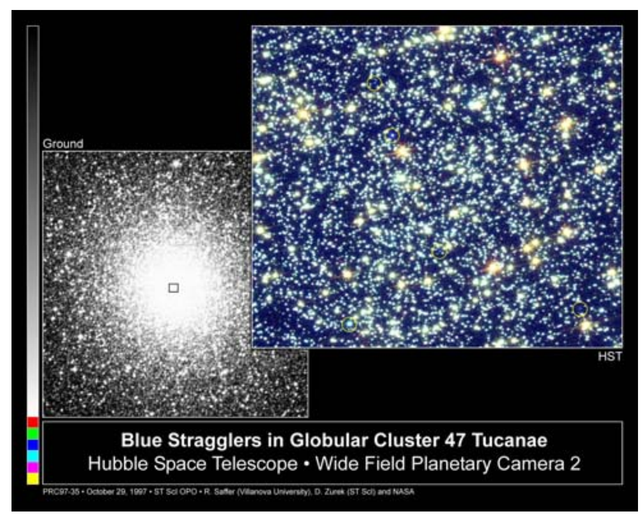
Our Sun

- A huge, hot ball of mostly hydrogen and helium (3% other stuff)
- Power output (luminosity) 3.26E+26 W
- Luminosity depends on surface area A (m^2) and temperature T (K)

$$\text{Luminosity} = P = \sigma A T^4, \text{ where } \sigma = 5.67\text{x}10^{-8} \frac{W}{m^2 K^4}$$

- It is 93 million miles from Earth. Intensity at the Earth is about 1000 W/m^2. That is like 10 100 W light bulbs every square meter

A sample of stars



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Stars

- The mass of a star determines most properties of a star: lifetime, color, size, luminosity
- Massive stars are very bright and hot, but they don't last very long.
- Stars are a balance between gravity and pressure from the internal heat – *hydrostatic equilibrium*
- Our sun is bigger than average.

Mass	Lifetime By
0.3 M_{sun}	1000
1.0 M_{sun}	10
3.0 M_{sun}	0.35
10 M_{sun}	0.025
60 M_{sun}	0.002

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What is Temperature?

- Old definition – It is the thing measured by thermometers
- Temperature is a measure of the average kinetic energy of molecules – higher T more motion.
- Each molecule can have a range of kinetic energies. Boltzmann Distribution
- Average kinetic energy

$$KE = \frac{1}{2}mv^2 \quad KE_{average} = \frac{3}{2}kT \quad k = 1.38\times10^{-23}\frac{J}{K}$$

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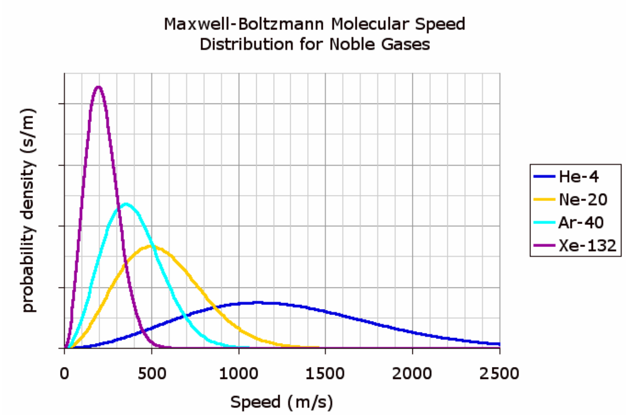
Boltzmann Distribution



Distribution of Noble gas speeds at 25 C.

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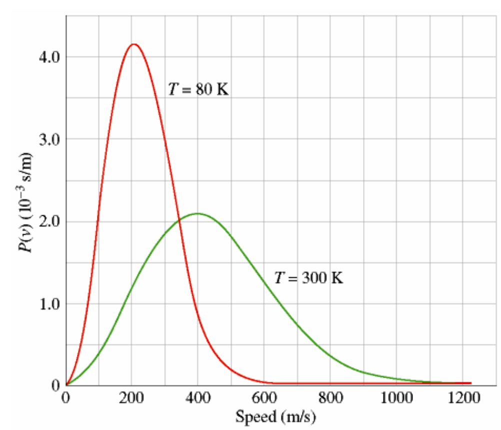
The distribution depends on temperature



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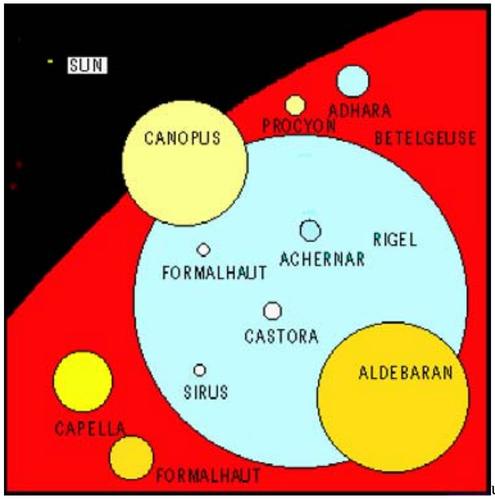
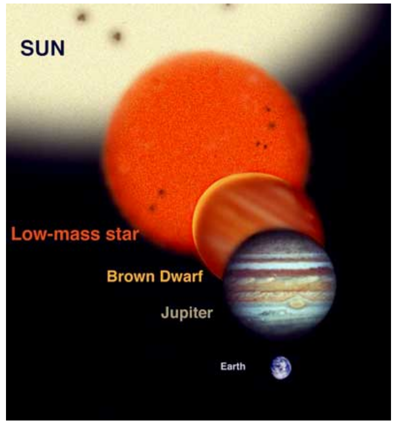
Relative Sizes of Stars





Blue – hot Red - cooler

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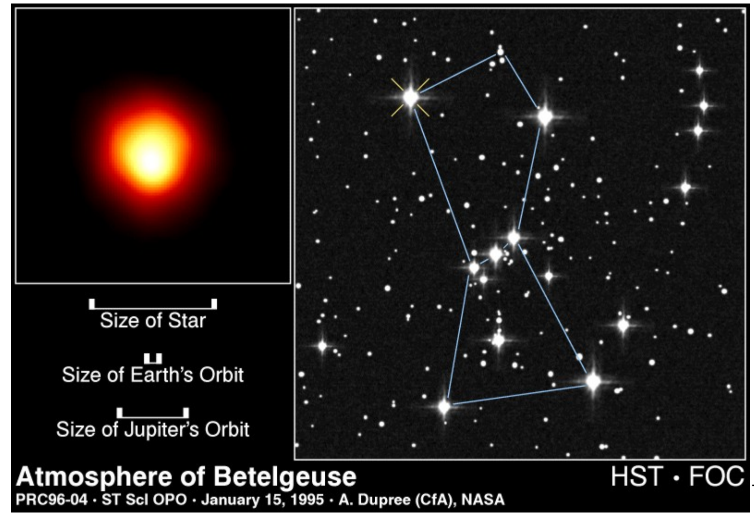
An example of a red supergiant



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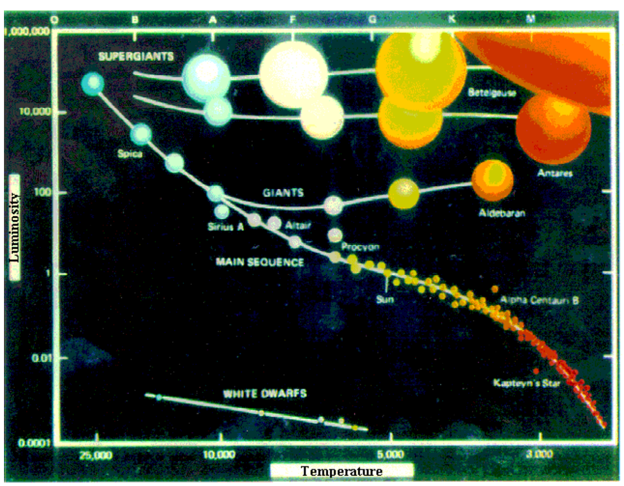
Hertzsprung-Russell Diagram



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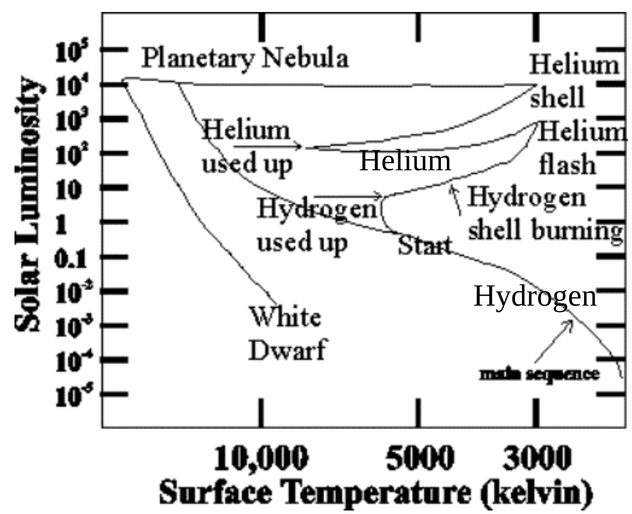
Evolutionary Path of our Sun



Hydrogen
10 By

Helium
1 By

White
Dwarf
many BY

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Planetary Nebula

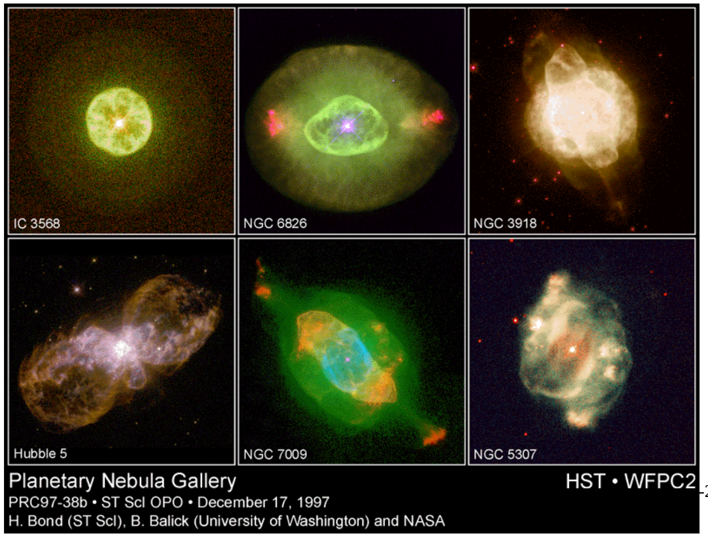

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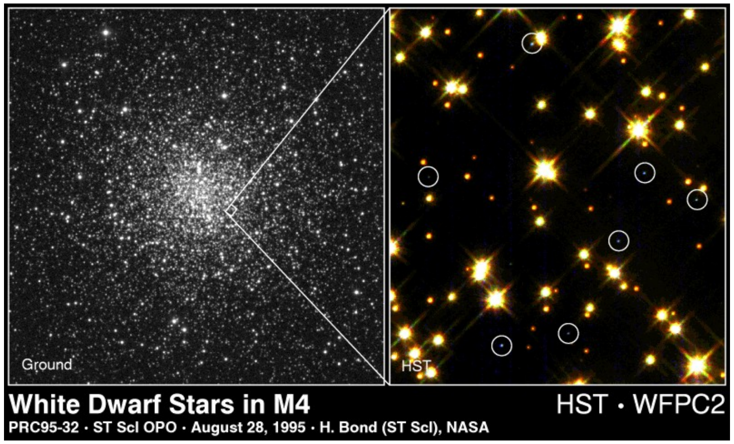
Image of White Dwarfs



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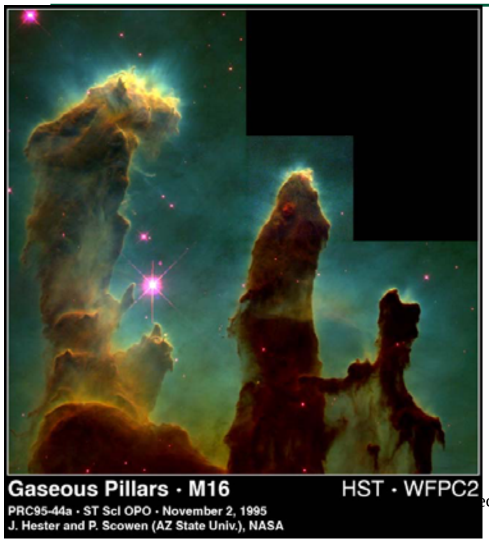
Star Birth – Giant Clouds of Gas and Dust



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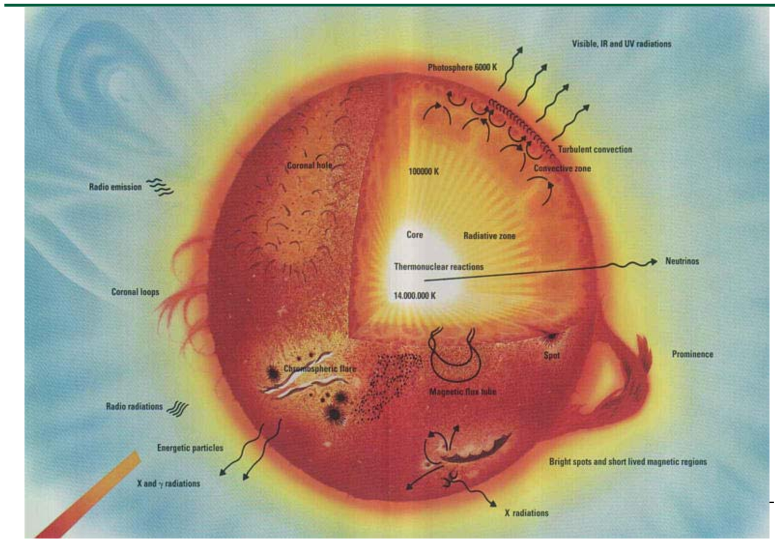
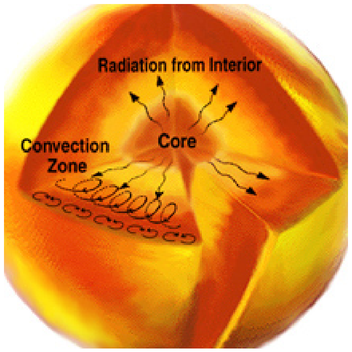
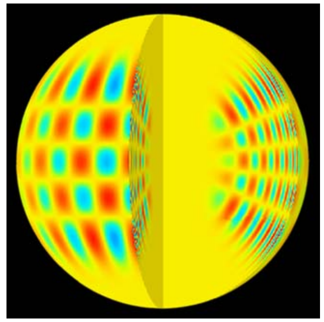
Our Sun is a complex object

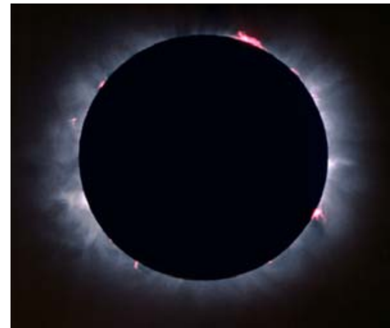


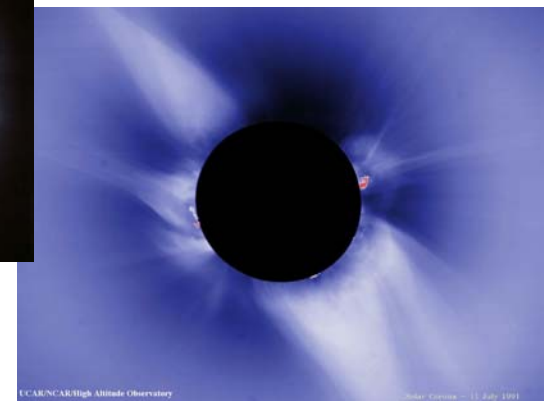
The Suns' Interior





The Suns Corona





Summary of evolution of stars