

ASTR 1020: Stars & Galaxies

December 13, 2013

- *Mastering Astronomy* Homework on **The Big Bang** is due tonight.
- Review for Final Exam: Tonight at 7:00 pm, EDUC 155.
- **Final Exam: December 14, 7:30 – 10:00 pm; Chapters: 1, 4, 5, 6, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23.**



Final Exam on Dec. 14

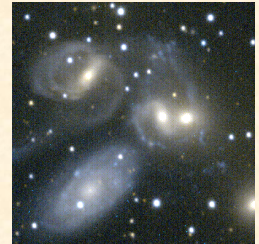
- 7:30 pm to 10:00 pm here.
- Study with a buddy!
- Chapters: **1, 4, 5, 6, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23.**
- Review 3 midterm exams, notes on class website, *Mastering Astronomy* assignments, clicker questions, key concepts, work sheets from recitation.
- Format: 40 multiple choice questions, 10 true-false, and 6 short-answer questions. Also, 1 extra credit question.

Be sure to bring to Exam

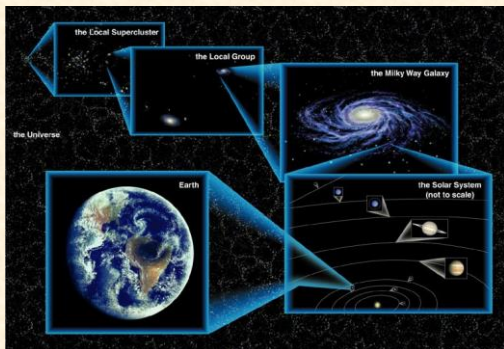
- A number 2 pencil or pen.
- **Your CU ID!** We will check IDs for this exam.
- One page (front and back) of notes for the exam.
- A calculator.

Course Goals

- To develop a broad view of what we know about the Universe
- To understand the forces that shape the Universe and its history
- To help you understand how we figured out all this stuff



1. The Scale of the Universe



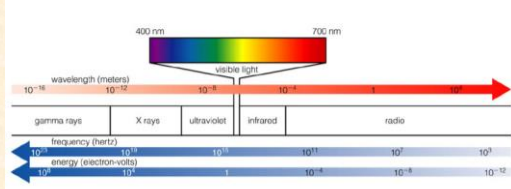
Matter & Energy

- Atoms: nuclei (protons & neutrons) + electrons
- Different forms of energy: kinetic, thermal, potential, radiation (light), mass-energy
- **Energy is always conserved!**

The Electromagnetic Spectrum

- Radio
- Infrared
- Visible light
- Ultraviolet
- X-rays
- Gamma-rays

=> In order of **increasing** photon energy, **increasing** frequency, and **DECREASING** wavelength.



Light and Matter

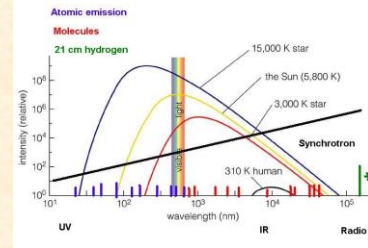
- **Four ways** to make light (including 2 from later chapters):

- Thermal spectrum

- Emission lines (absorption, too)

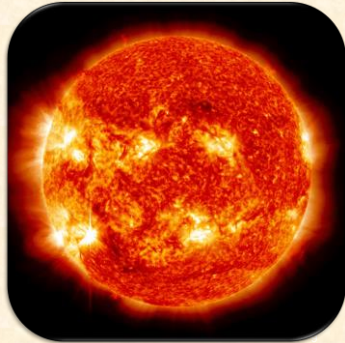
- Hydrogen: 21-cm emission line

- Synchrotron emission



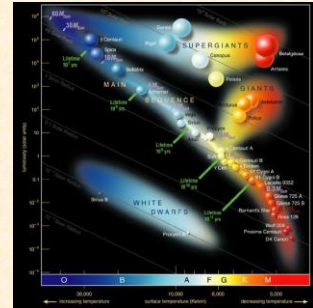
2. Stars

- The Sun
- Shines with energy released as hydrogen fuses into helium
- Overall fusion rate very stable- gravitational equilibrium
- Violent activity on the surface



Measuring the Stars

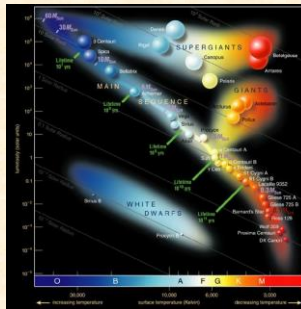
- Estimating distances via parallax
- Apparent brightness and distance \rightarrow luminosity
- Measuring temperatures via color, spectral type OBAFGKM
- Measuring masses via binary stars



The Hertzsprung-Russell Diagram

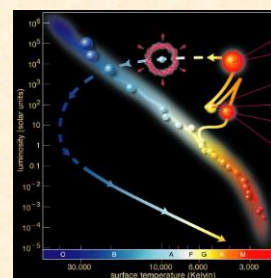
The Main Sequence

- More massive stars are rarer, hotter, brighter, shorter lived,
- Can estimate ages of star systems from "main sequence turnoff"



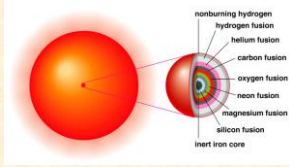
Stellar Evolution

- Star Birth
- Low mass stars:
 - Sequence of expansion and deflation in response to core nuclear burning
 - Red giant, planetary nebula, white dwarf



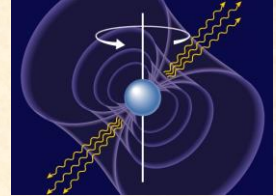
High Mass Stars

- Very rapid sequence fusing heavier elements up to iron
- Supernova explosion
- Neutron star or black hole remains



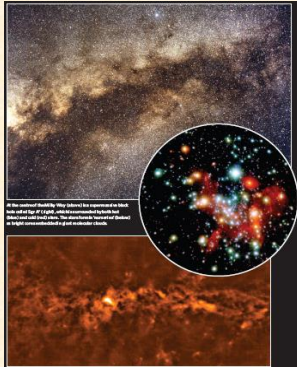
Stellar Graveyard

- White dwarfs (and the possibility of white dwarf supernovae)
- Neutron stars (possible pulsars)
- Black Holes



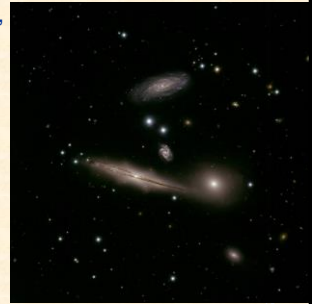
3. The Milky Way Galaxy

- Our home spiral galaxy: bulge, halo & disk
- Star-Gas-Star Cycle
- Gas, dust & stars
- A black hole in the galactic center!

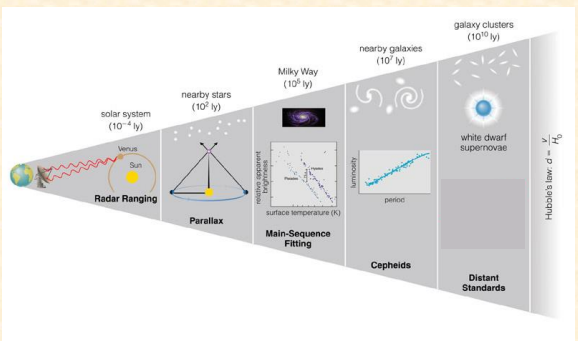


Other Galaxies

- Galaxy Types: spirals, ellipticals, irregulars
- Bulges/spheroids = older
- Disks = star forming stars today

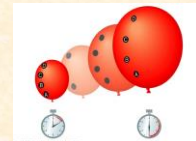
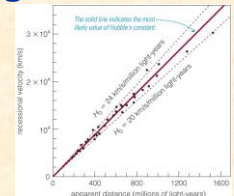


Measuring Distances through the Universe: the Distance Ladder



The Expanding Universe

- Hubble's Law:
 $v = H_0 d$
- The distances between galaxies are getting bigger!
- Running time backwards → age of the universe



Clicker Question: Which of the following is NOT an indication of Dark Matter

- a) Flat rotation curves for spiral galaxies.
- b) Gravitational lensing in Galaxy Clusters
- c) Acceleration of the expansion of the universe using white dwarf supernovae.
- d) Confinement of hot, X-ray gas in clusters of galaxies.

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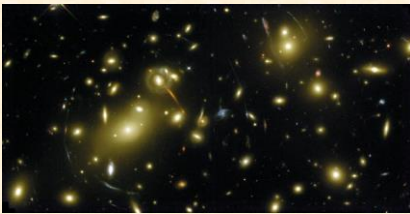
Clicker Question: Which of the following is NOT an indication of Dark Matter

- a) Flat rotation curves for spiral galaxies.
- b) Gravitational lensing in Galaxy Clusters
- c) Acceleration of the expansion of the universe using white dwarf supernovae. => This is dark energy!**
- d) Confinement of hot, X-ray gas in clusters of galaxies.

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4. Cosmology

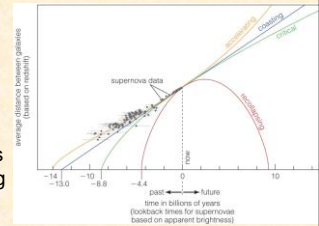
- Rotation curves, galaxy clusters (3 ways) suggest large amounts of **DARK MATTER**
- Probably an unidentified subatomic particle (WIMP)



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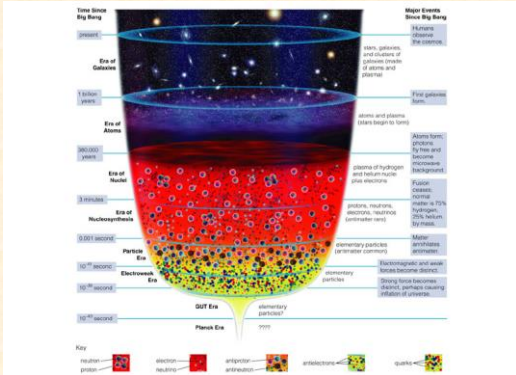
The Fate of the Universe

- Hubble constant sets the expansion rate for NOW
- Dark matter pulls expansion curves downwards
- Upwards curve suggests DARK ENERGY pushing against gravity!



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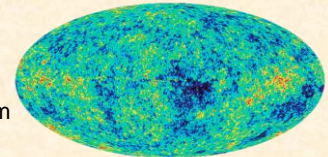
The Creation of the Universe



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Evidence for the Big Bang

- Expanding universe
- Cosmic microwave background
- Helium & Deuterium from the Big Bang
- Ages of stars
- Inflation



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Through all of this....

We explored the nature of matter and energy,

the sources of all light and warmth,

the origin of the elements of we are made,

our cosmic history,

our place in the universe

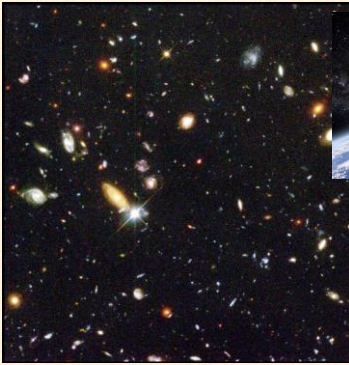


We shall not cease from exploration,
and the end of all our exploring
will be to arrive where we started
and know the place for the first time.

-- T. S. Eliot



You Now Understand the Universe!



**Our Star Trek
is complete!**



- See you tonight at 7 pm for the Final Exam review (EDUC 155).
- Final Exam on Saturday at 7:30 pm here in this room.

