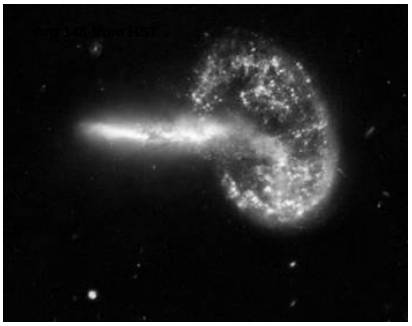
ASTR 1020: Stars & Galaxies

May 2, 2008

- Final Exam: May 5, 4:30 – 7:00 pm.
- Chapters: 1.1-1.2, 4.1-4.4, 5, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24.

Astronomy Picture & Video of the Day



Video of the "History of Everything"

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Final Exam on May 5

- 4:30 pm to 7:00 pm here.
- Study with a buddy!
- Chapters: 1.1-1.2, 4.1-4.4, 5, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24.
- Review 3 midterm exams, notes on class website, *MasteringAstronomy* 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.

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Be sure to bring to Exam

- A number 2 pencil.
- Your CU ID.
- One page (front and back) of notes for the exam.
- A calculator.

4

Review of the Course

Four sections:

1. Scales; matter, energy & light
2. Stars
3. Galaxies
4. Cosmology

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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

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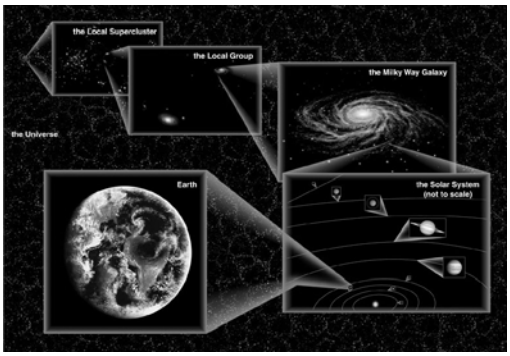
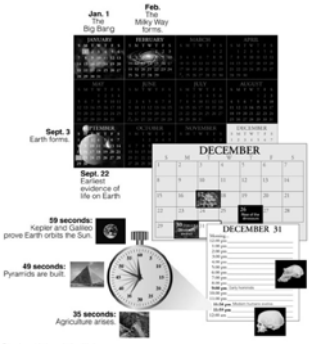
1. The Scale of the Universe



The Cosmic Calendar



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Matter & Energy

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

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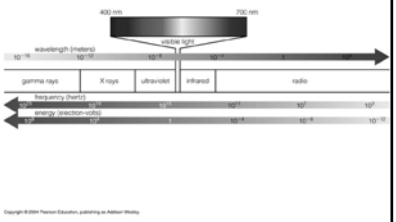
The Electromagnetic Spectrum

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

In order of increasing photon energy,

increasing frequency,

and DECREASING wavelength



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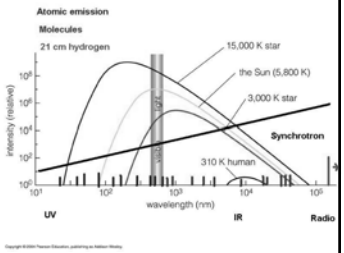
Light and Matter

- Four ways to make light (including 2 from later chapters):
- Thermal spectrum
- Emission lines (absorption, too)
- Hydrogen: 21-cm emission line
- Synchrotron emission



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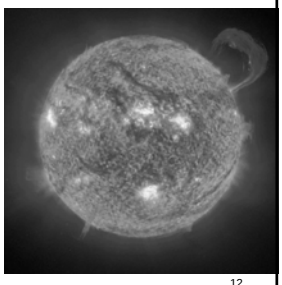
2. Stars

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



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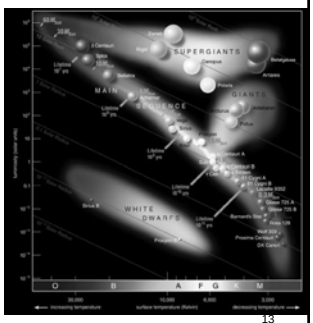
Measuring the Stars

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



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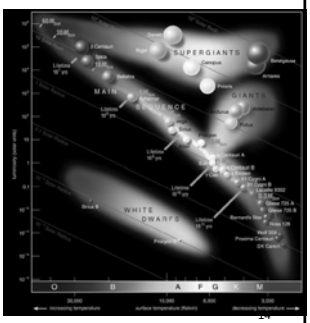
The Herzsprung-Russell Diagram

The Main Sequence

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



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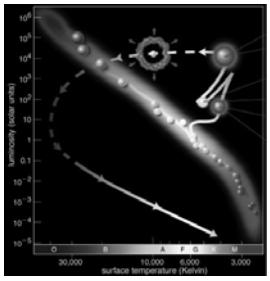
Stellar Evolution

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



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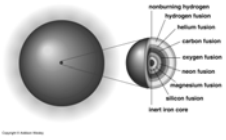
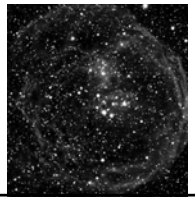
High Mass Stars

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





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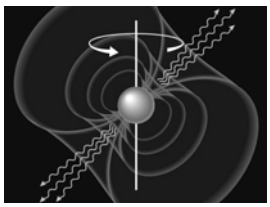
Stellar Graveyard

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



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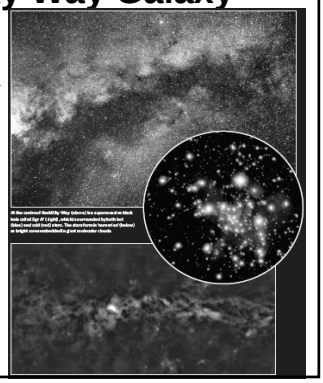
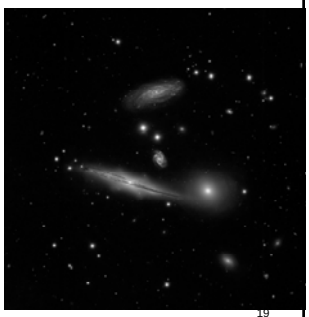
3. The Milky Way Galaxy

- 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, dwarfs
- Bulges/spheroids = older
- Disks = star forming stars today



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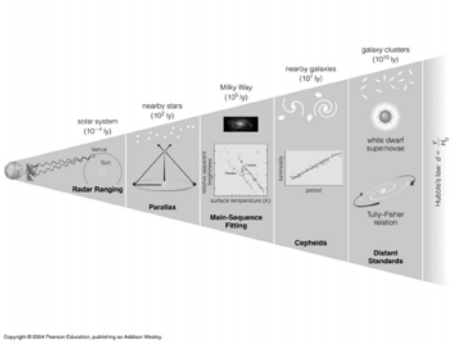
Measuring Distances through the Universe



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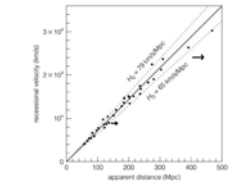
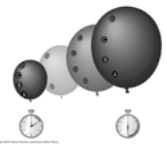
The Expanding Universe

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





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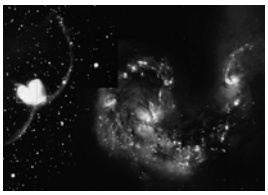
Galaxy Evolution

- Galaxy formation- using present-day properties to figure out how galaxies formed
- Galaxy interactions
- Active and starburst 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.
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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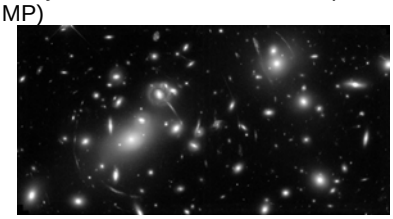
4. Cosmology

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



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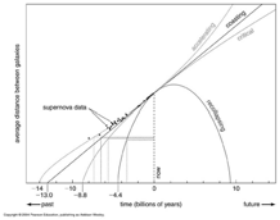
The Fate of the Universe

- 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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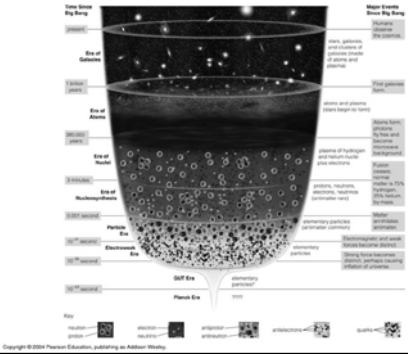
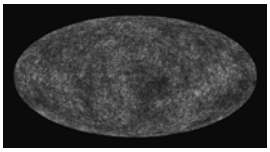
The Creation of the Universe



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….

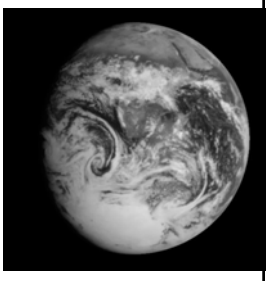
We explored the nature of matter and energy,

the sources of all light and warmth,

the origin of the elements of we are made,

our cosmic history,

our place in the universe



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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

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You: Understood the Universe!

Our Star Trek is complete!

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- See you Monday at 4:30 pm for the Final Exam!

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