

STARS, GALAXIES, UNIVERSE

- I. Goals for this course (Intro Notes, Unit I.)
 - A. Increase awareness of, and interest in, your celestial neighborhood
 - B. Improve your "scientific literacy"
 - C. Instill a "Cosmic Perspective" on your world
 - D. Contribute to your personal and professional growth

- II. A Quick Look at Teaching and Scientific Illiteracy (Intro Notes, Units II., III.)

- III. Science – a learning process (Intro Notes, Unit IV.)
 - A. Definition of Science
 - B. The practice of Science and its pragmatic, naturalistic nature
 - C. Facts, theories and "the heart of science"
 - D. The Scientific Attitude
 - E. Science vs. dogma & myth
 - F. Science as it relates to other areas

- IV. Critical Thinking (CT) vs. Black/White thinking (Intro Notes, Unit V.)
 - A. Eight aspects of CT
 - B. Scholarship
 - C. Impact on the world and reflections

- V. Pseudoscience/Superstition/Anti-intellectualism (Intro Notes, Unit VI.)
 - A. Characteristics
 - B. Contrasts with science (the Black Knight at the Bridge)
 - C. Some astronomically related examples & brief personal perspective

- VI. Starlight--what the naked eye can see
 - A. brightness and magnitudes
 - B. color and the electromagnetic spectrum
 - C. direction and coordinate systems (brief)

- VII. Using light to know the universe
 - A. Temperature
 - 1. definition
 - 2. scales

 - B. Planck's Radiation Law for ideal (black body) radiators
 - 1. Wien's Law (color as a fn. of temp.)

- 2. Stefan-Boltzmann Law (brightness as a fn. of temp.)
- C. Luminosity as a function of size and temp.
- D. Star spectra and what they tell us
 - 1. Kirchoff's Laws - three basic kinds of spectra

TEST 1 covers Assignments 1, 2, 3

- 2. quantum mechanics and atomic structure
- 3. temperatures
- 4. chemical composition
- 5. the spectral classification system

VIII. Doing modern astronomy

- A. How the oldest science became so modern
 - 1. observing in space--advantages
 - a. light pollution
- B. observing methods
 - 1. imaging
 - 2. spectroscopy
 - 3. photometry

IX. Star basics

- A. the problem of distance
 - 1. parallax
 - 2. the Astronomical Unit
 - 3. the parsec
- B. absolute magnitudes
- C. the H-R DIAGRAM
 - 1. description
 - 2. spectroscopic parallax
- D. the sizes and masses of the stars

TEST 2 covers Assignments 3N and 4

- E. Double stars - physical vs. optical
 - 1. visual binaries
 - 2. spectroscopic binaries
 - a. the doppler effect
 - 3. astrometric binaries
 - 4. value to astronomy of double stars
 - F. Stellar populations
- #### X. Stellar Evolution

- A. How do stars shine?
 - 1. The “Yin” and “Yang” of stars—gravity and pressure
 - 2. nuclear fusion and Einstein's famous equation: $E=mc^2$
 - 3. nucleosynthesis and the range of stellar masses
 - a. (example of fact + theory = understanding)
- B. Pre-main sequence phase (protostars and the formation of stars)
 - 1. nebula->critical density->Bok globule->protostellar disk->T Tauri-> β Pictoris
- C. Main sequence phase
 - 1. hydrogen core "burning"
- D. Post-main sequence phase
 - 1. ascent to the red giant phase
 - a. shell "burning"
 - 2. red giant/supergiant
 - a. energy depletion and the various ends to star life
 - b. planetary nebula-->white dwarf
 - c. supernova-->neutron star/pulsar, black hole
 - (1) the exciting case of Supernova 1987 A

TEST 3 covers Assignments 4N, 5, 6, and 6N

XI. Chances for ETL - life in the universe (textbook)

XII. Galaxies

- A. our Milky Way galaxy--a typical spiral galaxy
 - 1. Harlow Shapley & Henrietta Leavitt
 - a. the Cepheid variable P-L relation
 - b. size and our location
 - 2. structure from radio and optical studies
 - 3. the galactic year
 - 4. origin and explanation of stellar population types
- B. other galaxies
 - 1. morphology types
 - 2. clusters and superclusters
 - 3. quasars--the mystery
 - 4. their origin

XIII. the Universe--origin, nature, future

- A. Important cosmic discoveries of the 20th century to date (presented without theoretical interpretation)
 - 1. the expansion of the universe
 - a. The Hubble Relation
 - b. The Hubble Constant
 - c. quasars--the mystery solved
 - 2. 2.7 K cosmic background radiation (CBR)
 - 3. Very minute, but important, fluctuations in the CBR
 - 4. Recent discovery of an acceleration of the expansion of the universe--what does this mean?
 - 5. An approximate inventory of the universe's matter, dark matter, and dark energy
 - 6. Age of the universe settled

- B. The major theories on the origin of the universe
1. The logic behind the theories
 2. the Steady State Theory
 3. the Big Bang Theory
 - a. Inflationary Universe Theory — a BB theory "upgrade"
 - (1) the starting size of the universe and
 - (2) speculation that the origin was a QM statistical fluctuation from a non-zero "energy vacuum"
 - (3) prediction of "flat" universe, that the universal critical density, $\Omega = 1$, exactly
 - (4) better explains the thermodynamic equilibrium of the early universe as demonstrated by the CBR
 - b. the first 3 minutes
 - (1) speculation that the origin was a QM statistical fluctuation from a non-zero "energy vacuum"
 - (2) speculation that the origin was a result of a collision of universe "branes"
 - (3) origin of the fundamental forces
 - (a) Grand Unification Theories (GUTs)
 - (4) origin of the elementary particles
 - (5) the brief period of fusion
 - c. the time of "recombination"
 - (1) the de-ionization of the universe and the decoupling of matter and light energy
 - d. The "Dark Time"
 - e. the origin of the galaxies - a major puzzle
 - (1) discovery of the earliest fluctuations
 - (2) recent and continuing discoveries of the earliest galaxies
 4. the Oscillating Universe Theory
 - a. Is the universe open or closed?
 - (1) the Universe's expansion is speeding up! What does this mean?
 - (a) dark matter and dark energy
 - (b) does the neutrino have a miniscule mass?
 - (2) prediction by the Inflationary Universe Theory of universal critical density, $\Omega = 1$
 5. String Theory a.k.a. "The Theory of Everything"
 - a. Are there 7 more physical dimensions?
- C. Evidence supporting the Big Bang/Inflation
1. the expansion of the universe
 2. the 3 K CBR
 3. the faraway distribution of QSOs
 4. the cosmic abundances of He, D, Li⁷
 5. the W and Z⁰ particles of the electroweak force
 6. the very small fluctuations in the early universe ($\pm 30 \times 10^{-6}$ K)
 7. the darkness of the night sky — Olber's Paradox
 8. the evolution of the galaxies
 9. cosmochemical evolution (the cosmic impact of stellar evolution)
- D. On the possibility that there might be other universes ("branes") and that the cause of the BB might have something to do with them

TEST 4 covers Assignments 7, 8 and 8N; but not 9
