

**STARS, GALAXIES, UNIVERSE**

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Spring 2010 and after

- I. The Introductory Course Notes Set (Notes already in outline form, so only the major units are given here.)
  - A. Goals for this course (Intro Notes, Unit I., covered in Foundational Homework Ass't.)
  - B. A Personal Statement on Teaching (Intro Notes, Unit II., covered in Foundational Homework Ass't.)
  - C. U.S. Scientific Illiteracy (Intro Notes, Unit III., covered in Foundational Homework Ass't.)
  - D. Science – a learning process (Intro Notes, Unit IV., covered in class)
  - E. Critical Thinking (CT) Skills (Intro Notes, Unit V., covered in class)
  - F. Pseudoscience/Superstition/Anti-intellectualism (Intro Notes, Unit VI., covered in class)
  - G. The Popularity of Pseudoscience (Intro Notes, Unit VII., covered in Foundational Homework Ass't.)
  - H. Dangers of Pseudoscience (Intro Notes, Unit VIII., covered in Foundational Homework Ass't.)
  - I. Non-psychological Reasons for the Acceptance of Pseudoscience (Intro Notes, Unit IX., covered in Foundational Homework Ass't.)
  - J. Psychological Reasons for Acceptance of Pseudoscience (Intro Notes, Unit X., covered in Foundational Homework Ass't.)
  - K. Tests of Psychic Claims (Intro Notes, Unit XI., covered in Foundational Homework Ass't.)
  
- II. Starlight--what the naked eye can see
  - A. brightness and magnitudes
  - B. color and the electromagnetic spectrum
  - C. direction and coordinate systems (brief)
  
- III. 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. Stephan-Boltzmann Law (intensity as a fn. of temp.)
  
  - C. Luminosity as a function of size and temp.
  
  - D. Kirchhoff's Laws - three basic kinds of spectra

**TEST 1 covers Assignments: Foundational, 1, 2, 3**

IV. Doing modern astronomy

- A. How the oldest science became so modern
  - 1. Impact of Technology
  - 2. Impact of Computers
  - 3. Impact of the Space Program
  - 4. Impact of the great 20<sup>th</sup> century Theoretical Physics Advances
- B. Observing methods
  - 1. imaging
  - 2. spectroscopy
  - 3. photometry
- C. Observing challenges
  - 1. light pollution and more
- D. Advantages to observing in space

V. Star basics

- A. the problem of distance
  - 1. parallax
  - 2. the Astronomical Unit
  - 3. the parsec
- B. absolute magnitudes
- C. Spectroscopy applied to the stars
  - 1. quantum mechanics and atomic structure
  - 2. temperatures
  - 3. chemical composition
  - 4. the spectral classification system
- D. the H-R DIAGRAM
  - 1. description
  - 2. spectroscopic parallax
- E. the sizes and masses of the stars

**TEST 2 covers Assignments 3N and 4**

- F. 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
- G. The Mass–Luminosity Relation
- H. Stellar populations
  - 1. Pop I (e.g. sun)
  - 2. Pop II

VI. 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->  $\beta$  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**

VII. Comments on ETL - life in the universe (textbook, video)

VIII. 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

IX. 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 6 more physical dimensions?
  - b. Was that QM statistical fluctuation from a non-zero "energy vacuum" brought on by a collision of universe "branes" moving about in 10-D metaspace?

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,  $\text{Li}^7$
5. the W and  $Z^0$  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)

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

- X. Reasons for acceptance of pseudoscientific beliefs: non-psychological (Intro Notes)
- A. *Post hoc, ergo propter hoc* fallacy
  - B. Ignorance of science and philosophy (and see "D." below)
  - C. Widespread dissemination of misinformation
  - D. Innumeracy - mathematical illiteracy
- XI. Reasons for acceptance of pseudoscientific beliefs: psychological (Intro Notes)
- A. Physical reality vs. the perception of it
  - B. Memory selection effect
  - C. Cold reading
  - D. Mental blocks to information that tends to refute one's belief
  - E. Satisfaction of emotional need
- XII. Tests of Psychic Claims (Intro Notes)
- A. Philosophic and historic comments
  - B. Lack of scholarship and the widespread failure to make distinction between the equality of ideas and beliefs in a legal sense and the *inequality* of ideas and beliefs in terms of their validity or value
  - C. Competent tests do not support claims of the paranormal or supernatural, despite the widespread popularity of beliefs in those claims. (Includes some video examples.)
- XIII. Reasons for acceptance of pseudoscientific beliefs: non-psychological (For further reasons, see Intro Notes. You will be held accountable on Test 2 for only the reason listed below.)
- A. *Post hoc, ergo propter hoc* fallacy (a.k.a. the "false cause" fallacy)
- XIV. Reasons for acceptance of pseudoscientific beliefs: psychological (For further reasons, see Intro Notes. You will be held accountable on Test 2 for only the reasons listed below.)
- A. Physical reality vs. the perception of it – "objective reality vs. subjective reality"
  - B. Mental blocks to information that tends to refute one's belief
  - C. Satisfaction of emotional need
- XV. The Popularity of Pseudoscience (Intro Notes, Unit VII., read)
- XVI. Dangers of Pseudoscience (Intro Notes, Unit VIII., read)
- XVII. Reasons why people believe in pseudoscientific claims (Intro Notes, Units IX., X., read, covered in lab)

NOTE: Closer Examination of pseudoscience done in lab
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