Learning Goals & Outcomes for Astronomy 9610

Fall Term, 2014

Overall Course Learning Goals:

- to familiarize students with astronomical jargon and modes of research
- to give students experience applying physics to astrophysics
- to develop students' problem-solving skills

Learning Outcomes — after completing the course material, students should be able to:

1. **Introduction** (C&O Chapters 1, 3 and 6)
   (a) use astronomical units and describe celestial coordinates
   (b) solve problems involving stellar parallax
   (c) apply the electromagnetic nature of light to radiation pressure
   (d) apply the quantum nature of light to the blackbody radiation curve
   (e) describe how the flux and luminosity of astronomical sources are defined
   (f) do calculations with magnitudes and colour indexes
   (g) describe basic atomic structure and how it is used in interpreting spectra
   (h) make simple predictions of astronomical spectra using Kirchhoff's Laws
   (i) describe the concepts of resolution and seeing and how they shape astronomical observations
   (j) describe the main divisions of the EM in relation to astronomy at different wavelengths
2. **Interaction of Radiation with Matter & Stellar Atmospheres** (C&O Chapters 8 and 9)
   (a) understand thermal equilibrium and the Maxwellian velocity distribution
   (b) solve problems involving the Saha and Boltzmann equations for ionization/excitation
   (c) describe the basis of stellar classification using the Saha and Boltzmann equations
   (d) describe the observational HR diagram
   (e) define the different quantities used to quantify the radiation field and how they relate
   (f) describe the origin of stellar opacity and list major opacity sources
   (g) describe radiative equilibrium
   (h) explain the origin of the radiative transfer equation and derive simple solutions
   (i) apply radiative transfer to a plane parallel, grey atmosphere
   (j) explain the formation and diagnostic potential of spectral lines

3. **Stellar Structure** (C&O Chapters 7 and 10)
   (a) describe how binary stars are used to determine basic stellar parameters
   (b) derive the equation of hydrostatic equilibrium
   (c) explain the equation of state appropriate for stellar structure
   (d) make simple estimates for the Kelvin-Helmholtz timescale
   (e) describe the basic physical principles of nuclear reactions in stars
   (f) explain the pp chain and the CNO cycle
   (g) describe radiative and convective energy transport
   (h) describe the four fundamental equations of stellar structure and how they are used to build stellar models
   (i) make simple estimates for central pressures and temperatures of stars
   (j) derive the Lame-Emden equation for polytropic equations of state
4. **Stellar Formation and Evolution** (C&O Chapters 12 and 13)
   (a) discuss the viral theorem and the Jean's criteria; explain how these relate to star formation
   (b) derive the equation describing the homologous collapse phase of star formation
   (c) describe the steps in the star formation process
   (d) discuss the Hayashi track and it's relation to pre-main sequence objects
   (e) describe the theoretical HR diagram and how it is used to test stellar evolution
   (f) derive the equation of state for a fully degenerate, electron gas
   (g) describe the major steps in post-main sequence evolution
   (h) describe how star clusters can be used to test stellar evolution
5. **End States of Stellar Collapse** (C&O Chapter 15, 16 and 17)
   (a) describe the sequence of events leading to core-collapse supernova
   (b) describe the observational classification of supernova and their physical origin
   (c) describe the discovery of the first white dwarf, Sirius B
   (d) derive the M-R relationship for white dwarfs and the Chandrasekhar limit
   (e) describe white dwarf cooling
   (f) explain the origin of a limiting mass for neutron stars
   (g) describe the characteristics of pulsars
   (h) make simple calculations involving the Schwarzschild metric
   (i) describe the physical significance of the event horizon surrounding a black hole
   (j) describe the observational evidence for (stellar) black holes

6. **Milky Way** (C&O Chapters 12, 24)
   (a) describe the contents and state of different phases of the interstellar medium
   (b) do calculations relating to extinction, reddening and scattering
   (c) explain quantitatively how the shape and size of the galaxy are measured
   (d) describe the components of the Milky Way and their stellar populations
   (e) explain quantitatively how Galactic rotation is measured and dark matter inferred
7. **Extragalactic astronomy** (C&O Chapters 25, 27, 28)
   (a) list the different morphological types of galaxies and describe the range of properties (e.g. mass, luminosity, star formation history, environment) of each type
   (b) perform calculations with the most commonly-used galaxy *surface brightness profiles*
   (c) define *rotation curve, velocity dispersion*; use these quantities to compute a galaxy's mass
   (d) define the *Hubble constant* and explain how it's measured via the *extragalactic distance scale*
   (e) describe the properties of *galaxy clusters* and quantitatively show how they are used to infer the presence of dark matter
   (f) describe the observational properties of active galaxies
   (g) describe the basic features of models for *active galactic nuclei*; do calculations related to their accretion luminosity
8. **Cosmology and the early universe** (C&O Chapters 29, 30)
   (a) compare and contrast Newtonian and relativistic cosmology
   (b) describe the contents of the universe and their importance at different times in its history
   (c) explain concepts related to the *Cosmic Microwave Background: decoupling, last scattering, recombination, anisotropy*
   (d) compute the time evolution and geometric properties of single- and multi-component universes
   (e) compute observable properties in cosmology (e.g. luminosity distance, horizon distance)
   (f) explain the current evidence for an accelerating universe
   (g) explain how the concept of thermodynamic equilibrium relates to cosmology; and use it to calculate reaction rates and particle densities
   (h) explain how *primordial nucleosynthesis* works and its relation to properties of the universe
   (i) list some problems with standard big bang cosmology and their resolution

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