Course Goals & Learning Outcomes for Astronomy 2022A, 2014

Course goals: At the end of this course, students will be able to:

- describe the science of cosmology and its relation to other fields of science
- identify and describe cosmology's current unanswered questions
- explain how the scientific method and quantitative arguments are used in cosmology

Learning outcomes for specific topics — students will be able to:

1. Scale of the universe (Chapter 2, 12)
   (a) define and use the terms star, planet, galaxy, universe
   (b) define light year, astronomical unit and relate these to the size of the above objects
   (c) do order-of-magnitude calculations relating human scales of space and time to astronomical scales
   (d) define parallax, Cepheid, supernova and explain how these are used to measure distances
2. Forces in the universe (Chapters 3, 9)
   (a) define equivalence principle and explain what it has to do with Einstein's theory of general relativity
   (b) explain how general relativity is used in understanding the structure and evolution of the universe
   (c) compare and contrast the possible types of spacetime curvature
   (d) identify the 4 fundamental forces and describe their role in the past and present universe
   (e) explain the meaning of quantum as applied to forces in physics
3. The expanding universe (Chapters 4, 5)
   (a) describe the Cosmological Principle and its consequences
   (b) explain the meaning of scale factor and the different possible expansion histories for the universe
   (c) explain the effects of gravity, matter and energy on the expansion
   (d) describe the observational evidence for the expanding universe
   (e) define redshift and Hubble constant
   (f) explain Hubble's Law and interpret a Hubble diagram
   (g) describe the relation between the universe's expansion rate and its age
4. The early universe (Chapter 6)
   (a) explain what is meant by Big Bang theory and list some evidence for it
   (b) define and use the terms cosmic microwave background and recombination
   (c) give the relationship between time, average energy, and temperature in the universe
   (d) explain the concept of thermal equilibrium and its importance in cosmology
   (e) describe what happened (and approximate timescales) for the various eras in the early universe

5. Matter in the universe (Chapters 7–9)
   (a) define nucleus, element, isotope
   (b) list and correctly order the most abundant elements in the universe and explain where and how these elements are formed
   (c) describe how the abundances of elements changes with time
   (d) summarize the life cycle of stars
   (e) define anti-matter and explain why it is uncommon in the present-day universe
6. Dark matter and dark energy (Chapters 10–13)
   (a) define these two terms
   (b) describe the constituents of the universe and their approximate proportions
   (c) list and explain at least 2 pieces of observational evidence for dark matter and dark energy
   (d) compare and contrast the candidates for dark matter and dark energy, and the prospects for directly detecting them
   (e) explain how the possible fates of the universe relate to the matter and energy densities
   (f) explain the relations between the cosmological constant, vacuum energy and accelerating universe
7. Structure and scale (Chapter 14)
   (a) define homogeneity and isotropy and their use in the context of cosmology
   (b) explain the idea of the cosmological horizon
   (c) define inflation in the cosmological context and explain what it means
   (d) explain how the cosmic microwave background relates to the distribution of matter in the universe
8. Galaxies in the universe (Chapter 16)
   (a) describe the general size and shape of the Milky Way galaxy
   (b) list the different types of galaxies and their properties
   (c) explain the relationship between galaxies and supermassive black holes
   (d) explain the roles of gravity and angular momentum in the formation of galaxies and stars
9. Beginning (Chapters 18, 1)
   (a) explain what it means to talk about the 'beginning' of the universe
   (b) define the idea of the multiverse and discuss its implications
   (c) explain what quantum gravity and string theory have to do with the beginning of the universe
   (d) discuss the differences and similarities between historical and modern views of the universe

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