ASTR 0025 - FRONTIERS IN ASTRONOMY

Catalog Description

Prerequisite: Completion of ASTR 5 or 10 with grade of "C" or better
Hours: 54 lecture
Description: Topics at the forefront of astronomical research including an in-depth look beyond introductory astronomy. Emphasis on theoretical principles and supporting observational data. Includes relativity and warped spacetime, black holes, dark matter, quasars, gravitational waves, grand unified and super symmetry theories, and other recent developments in cosmology. (CSU, UC)

Course Student Learning Outcomes

- CSLO #1: Synthesize information from various sources (classroom instruction, online resources, etc.) to produce a coherent understanding of galactic/extragalactic astronomy.
- CSLO #2: Evaluate concepts in cosmology, relating concepts in underlying physics and observations to scientific frameworks of our universe's formation and evolution.
- CSLO #3: Critique new findings in the frontiers of astrophysics, assessing and appraising their conceptual frameworks.

Effective Term

Fall 2021

Course Type

Credit - Degree-applicable

Contact Hours

54

Outside of Class Hours

108

Total Student Learning Hours

162

Course Objectives

Through exams, assigned tasks, classroom participation, etc.., the student will:
1. Identify a variety of historical developments that lead to the development of Special Relativity
2. Compare mass, energy, and momentum concepts in Special Relativity with their non-relativistic counterparts
3. Present the interval as a reference frame invariant
4. Solve problems in time dilation, simultaneity, and velocity addition
5. Apply the Lorentz transformation to general problems in Special Relativity
6. Explain the concept of spacetime and its relation to Euclidean geometry
7. State the Equivalence Principle and its relation to inertial forces
8. Illustrate the ideas of a non-Euclidean geometry
9. Relate the theoretical ideas behind and the principle observational evidence for the General Theory of Relativity
10. Describe the Copenhagen interpretation of quantum mechanics, and how Einstein and others objected to “spooky action at a distance”
11. Relate modern physics perspectives of realism to quantum entanglement, and how locality is poorly treated in modern physics;
12. Describe the four fundamental forces of nature and their unification under the grand unified and supersymmetry theories
13. Correlate the structure of the universe to the fundamental forces
14. Describe issues of dark matter, and dark energy, as related to our modern understanding of the Concordance Cosmology
15. The students will identify the fascinating and mind-bending astronomical objects and conditions being discovered, on a nearly daily basis

General Education Information

- Approved College Associate Degree GE Applicability
  - AA/AS - Physical Sciences
- CSU GE Applicability (Recommended-requires CSU approval)
  - CSUGE - B1 Physical Science
- Cal-GETC Applicability (Recommended - Requires External Approval)
- IGETC Applicability (Recommended-requires CSU/UC approval)
  - IGETC - 5A Physical Science

Articulation Information

- CSU Transferable
- UC Transferable

Methods of Evaluation

- Classroom Discussions
  - Example: Students will select and object or topic to present upon. The other students in the class will analyze their cohorts’ presentations, focusing on drilling more deeply into the presentations. Example: The student develops and writes the following class proposal: “The standard model of particle physics has been very successful, but has shortcomings. Supersymmetry hopes to address these, by proposing that the fundamental particles of the universe and the fundamental forces are linked. For each fundamental fermionic particle (such as electrons), there would be a bosonic partner (i.e., selectron). I’m going to to talk about the strengths and weaknesses of this idea, and what would be required to test it.” The student presents on the topic to the class, with a handout for all the other students, which includes supporting imagery (at least 2 illustrations), vocabulary page of definitions, and 2 or more references, for 4-6 minutes, and then 2-5 minutes of Q and A afterwards. The student is graded upon time usage, knowledge of topic, logical flow of presentation, class handout, handling of Q & A period, and speaker engagement. Student also receives anonymous feedback from all their the class cohorts.)
- Objective Examinations
  - Example: Standard midterm and final exam consisting of a variety of question formats, evaluating all levels of performance according to Bloom's taxonomy (knowledge, understanding, application, analysis, synthesis, and evaluation.) Example exam question: How did the discovery of the cosmic microwave background discredit the Steady State Hypothesis?
- Problem Solving Examinations

    - Example: Students will calculate, for specific values of “c”, the values of the special relativistic parameters beta and gamma. This will allow them to further explore the consequences of relativistic, Lorentzian effects on momentum, time flow, and length. Example: You are a space traveler with a powerful spaceship. Your pet creature is suffering a vitamin deficiency and has only 1 year to live. To get a vitamin pack, you leave your space station at 0.85c and head for the creature’s home world 1 LY away. A) To the observers on the space station, how many years does it take for you to reach the home world? (Hint: no special relativity required…just the use rate equation, v=d/t!) B) Calculate the values of beta and γ. C) How many years do you (the traveler) perceive the travel time to take? [Hint: to=t/γ])
- Skill Demonstrations
    - Example: Homework exercises are assigned to evaluate student comprehension of weekly lectures and reading. Students will be assigned extraordinary astronomical objects mid-semester. The students will research these objects, learning where in the sky they are, and just why they are so bizarre. After writing a short paper on this topic, the planetarium projector will be used to display the sky, and one by one the students will point out the locations of their objects, and will lead a discussion on why the objects are so fascinating. Example #1: Write a 400+ word essay on the phenomenon of Active Galactic Nuclei. In your discussion, include the following terms: Seyferts, BL Lacs, quasars, radio jets, superluminal motion, supermassive black holes. Example #2: Observer A sees a 100m-long object traveling at 0.95c. Determine the Lorentz factor gamma; determine the object's contracted length; how long would a 10sec proper time interval appear to last, according to Observer A? Show all your work.

Repeatable

No

Methods of Instruction

- Lecture/Discussion
- Distance Learning

Lecture:

1. Students are taught the physics behind the Tully-Fisher relation for spiral galaxies. Then the student is presented with a set of galaxy spectra, and is asked to rank the galaxies in luminosity. Given relative brightnesses, the student is asked to calculate distances to galaxies. By exploring issues of distance calculations and also dark matter. The students will be learning about dark matter and distance calculations by direct analysis. By assessing their work, the instructor will be able to gauge the students’ level of understanding. (Objective 14)
2. After a review of the distance ladder, students will form teams, and analyze different sets of data or scenarios to calculate the distances to different astronomical objects such as via Type Ia supernovae. Each team presents their results to the rest of the class for further discussion and analysis. The students will be experiencing the same sorts of problems astronomers deal with in sleuthing the size of the Universe. The instructor can use this teaching time to guide the students to maximize their analytic approaches. (Objective 14)
3. Students have the option of turning in a term report on "popular" book on some topic related to cosmology in lieu of a select set of assigned problems. (Objective 15)
4. The students will watch a 15 minute video classic in physics called “Frames of Reference”. Afterwards, this video will be used as a framework for discussing Special Relativity. The students will have greater understanding of relativity, fictional forces, and will be primed for General Relativity. The instructor will lead this discussion as needed to raise critical thinking points. (Objective 2)

Distance Learning

1. The Students will watch a video made by the Instructor to help students understand quantum entanglement, and then we will work on a remote activity in which the students will become classically entangled! Each student will be given a choice to make. They will tell some (but not all) of each other (including the professor) the choice they made. This will be entangling students by differing amounts. We will analyze the degrees of entanglement set up by the various students in the classroom. (Objectives 10, 11)

Typical Out of Class Assignments

Reading Assignments

1. Reading from assigned text on a weekly basis. Example: Read Chapter on Special Relativity from textbook and be prepared to discuss in class. 2. Reading from supplemental material on a regular basis. Example: Read Hubble's original 1929 discovery paper on the redshifts of galaxies and recessional law. Classroom discussion to follow.

Writing, Problem Solving or Performance

1. Periodic homework exercises directed at developing problem solving skills. Example: Consider a spaceship traveling at .5C. It shoots out a probe at .8C. What is the velocity of the probe as measured by an observer in a stationary rest frame? 2. Term report on "popular" book on some topic related to cosmology.

Other (Term projects, research papers, portfolios, etc.)

1. In-class activity assignments on a periodic basis.

Required Materials

- Astrophysics for Physicists
    - Author: Arnab Rai Choudhuri
    - Publisher: Cambridge University Press
    - Publication Date: 2010
    - Text Edition: 1st
    - Classic Textbook?: No
    - OER Link:
    - OER:
- Astrophysics in a nutshell
    - Author: Dan Maoz
    - Publisher: Princeton University Press
    - Publication Date: 2016
    - Text Edition: 2nd
    - Classic Textbook?: No
    - OER Link:
    - OER:

Other materials and-or supplies required of students that contribute to the cost of the course.