Astro 105

The Stars and Galaxies

IUI Physics Department **Summer 2025**

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GENERAL INFORMATION

Description: An introductory survey of stars, galaxies, and cosmology. Including discussion about the various laws of gravity from Kepler, Newton, and Einstein. Plus other interesting information about spacetime.

Profiles of Learning: In this course, we encounter the four IUI Profiles of Learning (POL).

The two primary POLs for astronomy are

Problem Solvers: Work individually and with others to collect, analyze, evaluate, and synthesize information to implement innovative solutions to challenging local and global problems.

Communicators: Convey ideas effectively and ethically in oral, written, and visual forms across multiple settings, using face-to-face and mediated channels.

The remaining POLs are briefly encountered in introductory astronomy

Innovators: Build on experiences and disciplinary expertise to approach new situations and circumstances in original ways, are willing to take risks with ideas, and pose solutions.

Community Contributors: Are active and valued on the campus and in communities locally and globally. They are personally responsible, self-aware, civically engaged, and look outward to understand the needs of society and their environment.

Course Learning Objectives: This course is a General Education Course in the Life and Physical Sciences domain for colleges and universities in Indiana. Throughout the semester we address, multiple times, the six Learning Objectives of Astronomy A105:

(i) **How astronomical explanations are formulated, tested, and modified or validated.**

(ii) **Differences between scientific and non-scientific evidence and explanations.**

(iii) **Foundational knowledge and astronomical-specific concepts to address issues or solve problems.**

(iv) **Observational, quantitative, and technological methods to gather data and generate evidence-based conclusions.**

(v) **How theories describe, explain, and predict natural phenomena.**

(vi) **How to locate sources of astronomical evidence to construct arguments.**

How Learning Outcomes are Assessed: During Fall and Spring: There will be 6 quizzes, spaced about every week (except exam weeks), that cover the material during the previous week(s). There will be two (75-minute) exams administered during the semester. There is a Take-Home Project (worth about 4 quizzes) due towards the end of the course. Finally, there will be a comprehensive final exam (2 hours) administered during finals week. During Summer: Two exams, with the option to take a third exam.

Profiles of Learning Integration With Learning Outcomes: Listed below are: (1) *Learning Objectives (Outcomes)* and examples of how they (2) Integrate with the Profiles of Learning (POL).

(i) *How astronomical explanations are formulated, tested, and modified or validated:* As *Problem Solvers* we examine the stellar theory of Kelvin and Helmholtz and from the analysis we show it cannot be correct. And as good *Communicators* we learn how to explain to the layperson, the requirement for a modern theory of stellar evolution based on nuclear physics that incorporates one very important element from quantum theory.

(ii) *Differences between scientific and non-scientific evidence and explanations:* As *Communicators*, we review the earlier stellar classifications which were observationally based simply on a star's brightness and color. We contrast this with modern theories that recognize that distance to a star plays a role in brightness and the fusion rate will also modulate brightness. Also importantly, the laws of astrophysics, including some quantum effects, predict changes in color during stellar evolution. Hence both stellar brightness and color are not static, but rather dynamic characterizations.

(iii) *Foundational knowledge and astronomical-specific concepts to address issues or solve problems:* As *Problem Solvers* we first review the modern stellar evolution theories. From this, we show how one can predict the end-state (roughly a billion years into the future) of a given star based solely on its birth mass: Lower mass stars become white dwarfs, moderate mass stars become neutron stars, and the high mass stars end as black holes.

(iv) *Observational, quantitative, and technological methods to gather data and generate evidence-based conclusions:* Astronomers are *Innovators*, we need accurate geological dating of Mars' and Moon's surfaces to support the development of general stellar evolution theories. Because of recent innovations, we have leveraged advances in micro-electronics to build advanced soil-sampling devices; new data from the samples (Mars) have aided in the refinement of stellar evolution theory.

(v) *How theories describe, explain, and predict natural phenomena:* As *Problem Solvers* we review Big Bang Theory, and the origin of hydrogen, helium, and lithium and their observed quantities in our solar system. We discuss the theory of the abundances of each and present the measured/observed abundances data. An important goal in astronomy is to explain the origin of matter in our universe. We discuss how the Big Bang Theory gives us the observed concentrations of virtually every element found in the Periodic Table.

(vi) *How to locate sources of astronomical evidence to construct arguments:* Astronomers are *Communicators*, as a student in this course, you will be required to explain/show why the motion of Mercury around the sun was an important first test of Einstein's Theory of General Relativity (GR). You will describe the shortcomings of Newton's Law of Gravity and contrast it with the many advantages of GR. But you will also explain why we have not completely abandoned Newton's Law of Gravity, *i.e,* we don't use GR to explain a block sliding down an incline.

Text: *THE COSMIC PERSPECTIVE* **Stars, Galaxies & Cosmology** by Bennett, *et. al.*, any recent edition, Pearson Publishing. NOTE: This text is quite extensive and in most cases provides too much detail. In the end, you are responsible for knowing and understanding my lectures notes. You should use the text to supplement the lecture notes (*i.e,* "fill in the details") – the exams are based on the lecture notes.

Web: `http://woodahl.physics.indianapolis.iu.edu/Astro105Summer/` Mark this website in your browser. At the web site you will find: Syllabus (which you are reading now) in PDF, and links to the media.

Contact: You should try use your official "`name@iu.edu`" email when contacting me. Others may be rejected by the UITS junk email filters.

Exams: There will be two exams and a third optional exam as listed in the schedule. **There are no makeups on any exams!** Exam study guides will be posted. Do not miss an exam – you will receive a zero for that exam (there are no exceptions). Furthermore, no exams will be given early – if you have a an outside unmitigated conflict with an exam date/time, drop the course now. Exam scores will be posted on Canvas approximately a few days after each exam.

Withdrawal: If it is necessary for you to drop this course, please do so officially, filling out all the necessary paperwork. Otherwise per University policy you will receive an F on your transcript.

Telescopes: The department has several Dobsonian telescopes (altazimuth-mounted Newtonian telescope first designed by Dobson in 1965) for student use. They can be used to view some features of the moon (e.g. Lunar Maria). They may be borrowed for a few weeks at a time. Please check with me for details.

Weighting: The final letter grade will be determined from your cumulative point total based on the following weights:

Exams	100%

Grades: Standard percentages for the letter grades are employed.