Physics 632, “The Physics of Astrophysics II” Syllabus
Spring 2018

General Information

Instructor: Mark Henriksen
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Office: Physics 414
office hours: TuTh 11:15-noon
Location: Physics 414
Time: TuTh 10-11:15

Course description

The purpose of this course is to provide graduate students who are interested in a career in astrophysics a general background in the field. A good background includes factual knowledge, the tools of astronomy, and how to use both to elucidate and answer questions. This is basically what a researcher does. A strong background in stellar interiors and atmospheres in necessary for all astrophysical research areas: from stars to cosmology. This course will also include nebular physics, which addresses using line emission to obtain the physical conditions in gases. It is an interesting journey, which involves using our background in statistical mechanics and quantum mechanics to prepare for physics research. Along the way, we also learn some interesting things about our Universe on the largest scales.

Grading procedures

Grades will be calculated using the following template: (1) attendance and class participation – 10%, (2) two midterms - %40, (3) homework – 20%, (4) final exam – 30%. Please note that exams will be based on lecture material so that good attendance and attention in class is required to do well.

Scope of this Course

The following topics will be covered, in order, during lectures. The lecture material is my book and is self-contained. However, you are encouraged to ask questions to further your understanding. You are also encouraged to read related material in the following books.

Primary reference book: “Modern Astrophysics”, Ostlie and Carroll, 2nd edition, Pearson. **Secondary references**: “Stellar Interiors”, Hansen, Kawaler, and Trimble, 2nd edition, A&A Library, “Astrophysical Concepts”, Harwit, 4th edition, A&A, Library, “Stellar Structure and Evolution”, Kippenhahn and Weigert, A&A Library, Rybicki G., & Lightmann, A., 1976, “Radiative Processes in Astrophysics”, Wiley Science, ISBN 0-471-82759-2

1. Classification of spectra: MB distribution, Boltzmann equation, Saha equation, Spectral types, HR Diagram
2. The radiation field, Radiative Transfer – macroscopic view, simple cases, Brightness temperature and BB temperature
3. The Microscopic View of Radiative Transfer, Einstein Coefficients, Detailed Balance and Thermodynamic equilibrium, stimulated emission
4. Scattering as a random walk, a physical understanding of optical depth
5. Full Radiative transfer including scattering
6. Transport of radiation through a stellar atmosphere, Rosseland mean opacity
7. Thermal energy conduction (“heat flux”)
8. The structure of spectral lines: line shape, natural broadening, Doppler broadening, pressure broadening, Voight profile, curve of growth, abundances
9. Mean molecular weight
10. Basics of Nuclear astrophysics: probability of decay, binding energy, PPI chain, nuclear timescale in stars, KH timescale, PPII, PPIII branches, abundances
11. Nuclear reaction rate
12. Equations of stellar modeling
13. Convection
14. Derivation of the Lane-Emden equation, solutions
15. Star Formation: Jean’s Mass, B-E mass
16. Gravitational instability, linearization
17. Free-fall collapse, application to star formation
18. The effect of magnetic field on collapse
19. Hayashi Track

20. Initial mass function
21. Visible effects of star formation: HII regions, T-Tauri stars
22. Evolution off the main sequence: 5 solar mass star
23. Evolution of 8 Solar mass star
24. variable stars: pulsating stars and pulsars, magnetic dipole radiation
25. Equation of state for electron degeneracy, application to white dwarfs, Chandrasekhar limit
26. Observation and evolution of white dwarfs
27. Binary accretion
28. Neutrinos
29. Gamma-ray bursts
30. Nebular Astrophysics with applications to AGN, emission line galaxies, stars, the IGM

Schedule of Exams

Midterm I: March 13
Midterm 2: May 7
Final Exam: May 22, 10:30-12:30

Homework Assignments

Homework is assigned on Tuesday and collected the following Tuesday. CO is Carroll and Ostlie, H is Hansen, Kawaler, and Trimble, RL is Rybicki and Lightmann

1. CO: 8.6,8.12, 3.9, 3.14, 3.18
2. CO: 9.7,9.8,9.16, RL: 1.2,1.5
3. CO: 9.20,9.23, RL: 1.7(a), H: 4.9
4. CO: 5.15
5. CO: 9.25,9.27,10.4,10.8, 10.12,10.13

6. CO: 10.17, 10.18, 10.24, H: 5.3
7. CO: 12.7,12.11,12.15
8. CO: 12.19, 13.7, H: 2.7, 14.7,14.8,15.6,15.12
9. CO: 16.1,16.12, 16.14,16.18,16.22
10. Handout HW, CO: 18.5,18.13
11. Handout HW I on nebular physics
12. Handout HW II on nebular physics

Policy on Academic Integrity

"Academic integrity is an important value at UMBC. By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty, and they are wrong. Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal."

Student Support /Disability Services

"UMBC is committed to eliminating discriminatory obstacles that may disadvantage students based on disability. Services for students with disabilities are provided for all students qualified under the Americans with Disabilities Act (ADA) of 1990, the ADAAA of 2009, and Section 504 of the Rehabilitation Act who request and are eligible for accommodations. The Office of Student Disability Services (SDS) is the UMBC department designated to coordinate accommodations that would allow for students to have equal access and inclusion in all courses, programs, and activities at the University."

Achieving Course Goals and Meeting Academic Expectations

Successful students in this course attend all classes and take notes. They are attentive and ask questions, occasionally. They complete all homework assignments on time. They review for exams. Most importantly, they either begin the course with adequate preparation or they fill in their missing background, as needed.