ASTR 2400: The Physics of Stars (winter)

Calendar description: One of the major scientific achievements of the 20th Century was the quantitative understanding of stars. This course reviews these advances including the spectral classification of stars, the Boltzmann and Saha equations, radiative transfer and stellar atmospheres, the equations of stellar structure, and the interiors of hydrogen burning stars such as the Sun.

Contents

Overview

This is a course on stellar astrophysics with focus on stellar atmospheres using the radiative transfer equations, and stellar interiors using the equations of stellar structure. It is the first time the student is exposed to concepts such as emissivity, source function, the gray approximation, hydrostatic equilibrium, and energy transport in the stellar interior. A primary aim of this course is to provide students with an understanding of how stars generate energy and the processes that modify this energy as it propagates through the star.

Prerequisites

ASTR 2100 Foundations of Astrophysics

From ASTR 2100, the student will have a quantitative familiarity with the concepts of colour photometry, blackbody radiation, flux and luminosity, magnitudes, luminosity-temperature-radius relation for blackbodies, and the Bohr model of the atom. The latter was also covered in PHYS 1500 (Introduction to Modern Physics)

Dependent courses

ASTR 3400 Interstellar Matter and Stellar Evolution

The unit on stellar evolution will require the student to have a thorough understanding of the stellar interior equations and simple schemes for computing stellar structure. In addition, the instructor of ASTR 3400 will need the student to have a good grasp of radiative transfer as well as absorption and line emission when discussing the ISM, and how it is modified by the life-cycle of stars.

ASTR 3500 Galaxies and Cosmology

To understand galactic structure requires a good understanding of one of its main constituents, namely stars. More specifically, ideas in radiative transfer will be used throughout this course.

Student Outcomes

A student completing ASTR 2400 will:

1. learn how astrophysicists treat radiation and opacity;
2. correlate data tables and find trends in data;
3. use elements of calculus to formalise an astrophysical problem.

Typical problems a student completing ASTR 2400 should be able to solve include:

1. When will a spectral line be seen in emission or absorption?
2. How does metallicity/surface gravity affect the appearance of a spectral line?
3. Considering equations of stellar structure, why are massive stars more luminous and why do they exhaust their fuel sooner than less massive stars?

Curriculum

1. spectral classification of stars
    - the physical basis of spectral classification
    - the Hertzsprung-Russell diagram
2. stellar atmospheres
    - the radiation field
    - gas opacity
    - radiative transfer

- spectral line profiles

3. stellar interior and stellar structure
   - hydrostatic equilibrium
   - equation of state
   - energy generation
   - energy transport
   - stellar structure modelling

Suggested texts

An Introduction to Modern Astrophysics by Carroll and Ostlie (ISBN) has traditionally been used for this course. The relevant chapters are 8, 9, and 10. This text is practical only if it is adopted for the other advanced courses in ASTR as well, but is inappropriate for this course alone as its scope is far beyond what this course needs.

Introduction to Stellar Astrophysics Volume 2: Stellar Atmospheres by Böhm-Vitense (ISBN 0 521 34870 6) and *Introduction to Stellar Astrophysics Volume 3: Stellar Structure and Evolution* by Böhm-Vitense (ISBN 0 521 34871 4) in combination would cover the entire course well.

Notes to the instructor

1. In previous years, *binary stars* was included as part of the curriculum for this course. It has been moved to ASTR 1100 (Introduction to Astrophysics) in keeping with making ASTR 2400 more of a *physics* course rather than a *survey* course of stellar properties, which is more the role of ASTR 1100.

2. If Carroll and Ostlie is to be used for this course, it is highly recommended that the instructor consult with other instructors of advanced ASTR courses to see if they will also be using this text. If not, asking the student to purchase this very expensive and expansive text for this course alone is discouraged.