ASTR 3400: Interstellar Matter and Stellar Evolution (fall)

Calendar description: This course examines the nature of neutral and ionised interstellar clouds and the onset of star formation. Concepts introduced in ASTR 2400.1(.2) are used to show how the initial mass of a "protostar" largely determines its place on the "main sequence" as a star, its internal structure and energy production, and the nature of its death, whether it be as a white dwarf, neutron star, or a black hole.

Contents

Overview

This course describes the physics of the interstellar medium (ISM) and the evolution of stars. The concepts covered by studying the ISM are widely applicable to many areas of astronomy (*e.g.*, IGM, AGN, accretion discs). The evolution of stars introduces the student to compact objects and related processes.

This course is cycled with ASTR 3500 (Galaxies and Cosmology).

Prerequisites

ASTR 2400 Physics of Stars

Students will bring from ASTR 2400 (and its prerequisite, ASTR 2100, Foundations of Astrophysics) a good understanding of the stellar interior equations, simple schemes for computing stellar structure, radiative transfer throughout the interior and atmosphere of a star, the origin of absorption and emission lines, the Saha equation, and opacity. The student will know about the ISM and some very general properties, but will know little of how the ISM affects and is affected by the life-cycle of a star.

Dependent courses

none

Student Outcomes

The overall aim of ASTR 3400 is to provide students with an understanding of the processes in the ISM and the evolution of stars. Typical problems and questions a student completing ASTR 3400 should be able to answer include:

1. How does the pre/post main sequence evolution depend on stellar mass?
2. What is the maximum luminosity of a star in hydrostatic equilibrium?
3. What is the Jeans mass/length and Jeans criterion?
4. What is the Strömgren radius?
5. Explain why radius and mass are inversely correlated for white dwarfs and neutron stars.
6. What is degenerate matter?
7. Why do stars pulsate?

Curriculum

1. the process of star formation
    - the role of the ISM and ISM diagnostics
    - Mie Theory
    - formation of protostars
    - pre-main sequence evolution
2. post-main sequence evolution
    - late stages of evolution
    - the evolution of massive stars
3. stellar pulsations
    - pulsating stars
    - cepheids
    - instability strip
4. degenerate stellar remnants

- white dwarfs
- physics of degenerate matter
- Chandrasekhar limit
- neutron stars and pulsars
- accretion discs

Suggested texts

1. *An Introduction to Modern Astrophysics* by Carroll and Ostlie (ISBN) has traditionally been used for this course and follows the curriculum well. The relevant chapters are 12–15, inclusive. 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.

2. *Astrophysics of gaseous nebulae and active galactic nuclei* by Osterbrock and Ferland (ISBN 1-891389-34-3) describes the ISM portion of this course well and is up-to-date (new edition in 2006). It is presented at a higher level and is more suitable for graduate students, but can provide nice reference material.

3. *The physics and chemistry of the interstellar medium* by Tielens (ISBN 0-521-82634-9) is also up-to-date and complete with regards to the ISM. The level is appropriate for senior undergrads, but stellar evolution would need to be supplemented. If, for example, *Introduction to Stellar Astrophysics Volume 3: Stellar Structure and Evolution* by Böhm-Vitense (ISBN 0 521 34871 4) were used for ASTR 2400 (Physics of Stars), it could provide the supplementary material for stellar evolution.

Notes to the instructor

1. 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.

2. The instructor may wish to consult with the instructor for ASTR 2400 (Physics of Stars) on texts, since many texts on stellar interiors also cover the subject of stellar evolution and could serve to supplement the ISM text or notes used for this course.