



The University of Sydney

Senior Physics Semester 2, 2006

Astrophysics

(PHYS 3x71, 3x72, 3x75, 3x77, 3x78, 3x79)

MODULE OUTLINE

This module introduces one of the most important physical processes in astrophysics – radiative energy transport – and its application to stellar atmospheres and beyond. This leads into the study of physical processes in the interstellar medium and galaxies, including quasars and other active galactic nuclei.

Lectures

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The module consists of a total of 19 lectures in Semester 2, 2006. A week-by-week timetable can be found at the Senior Physics website (www.physics.usyd.edu.au/ugrad/sphys/sp_choosing.html). Most lectures will be held in LT5. Two lectures will be split between ADV (39xx) and REG (30xx) classes, with ADV remaining in LT5 and REG moving to LT4. In addition to the ADV/REG split lectures, some lecture material will be marked as ADV only and will be thus non-examinable for those in the REG stream.

ADV/REG split lectures: Wed. 4 Oct. (Lec. 10) & Wed. 18 Oct. (Lec. 16).

Assessment

There will be 2 assignments contributing a maximum of 25% to the total assessment for this module. Assignments should be completed individually and handed into the Student Support Office by 5pm on the due date. You may discuss the questions with your peers and the course lecturers. Ensure your script is marked with your name, SID, and unit code. The final exam constitutes 75% of the total assessment for this module. The learning outcomes for provide a guideline for examinable material.

Assignment due dates:

Assignment 1: Friday 6 Oct. (Wk. 10)
Assignment 2: Friday 20 Oct. (Wk. 12)

Course Content:

Lecs. 1–6:

- Radiation – basic definitions: the radiation field, specific intensity, flux, moments, properties of blackbody radiation.
- Radiative Energy Transport I – emission and absorption coefficients, optical depth, source function, formal solution to the radiative transfer equation, applications to stellar atmospheres.
- Radiative Energy Transport II – local/strict thermodynamic and statistical equilibrium: emission, absorption and scattering processes, Maxwell, Boltzmann and Saha relations, Einstein coefficients.

Lecs. 7–11:

- Radiative Processes in the Interstellar Medium I – collisional ionisation in gaseous nebulae, photoionisation in star-forming regions, shock ionisation in supernova remnants, optical/radio recombination and continuum emission

- Radiative Processes in the Interstellar Medium II – radiative transfer effects in multiphase components (e.g. HI, HeI, HII regions), radiative properties of dust and heavy elements, ADV only: numerical solutions to the general radiative transfer problem in the ISM (e.g. MAPPINGS)

Lecs. 12–17:

- Galaxies I – the Milky Way as a galaxy: stellar motions and populations, mass-to-light ratio, halo mass, spiral structure and star formation; other galaxies: ellipticals vs. spirals, surface brightness, rotation curves
- Galaxies II – active galaxies: observational classification scheme (quasars, radio galaxies, Seyferts, blazars etc.), the standard AGN paradigm of black hole accretion, physical processes in the narrow-line and broad-line regions and the radiative transfer problem therein, application of the radiative transfer equation to quasar absorption lines.

Lecs. 18,19: Revision of examinable material.

Learning outcomes:

- Radiative Energy Transport:
 - ◇ recognise the blackbody spectrum and Stefan-Boltzmann law
 - ◇ write down and explain the radiative transfer equation (RTE) and know how to apply it quantitatively to derive simple stellar atmosphere models
 - ◇ understand the concepts of optical depth and local/strict thermodynamic equilibrium
 - ◇ understand how emission and absorption processes are related to the statistical relations of Maxwell, Boltzmann and Saha.
- Astrophysics of the Interstellar Medium:
 - ◇ explain the processes of collisional, photo- and shock ionisation and give astrophysical examples of where they are important
 - ◇ understand how these processes are incorporated into the RTE and why numerical methods are useful for solving these problems
 - ◇ recognise and explain the observational properties of the different components of interstellar gas (e.g. HI, HII regions, molecular clouds) and interstellar dust
- Astrophysics of Galaxies:
 - ◇ understand the basic physical properties of the Milky Way galaxy, as deduced from measurements of stellar motions, mass-to-light ratio, and observations in different wavebands
 - ◇ recognise the morphological classification of other galaxies
 - ◇ have a basic understanding of the the internal dynamics of galaxies
 - ◇ know what velocity dispersion is and the role of dark matter
 - ◇ know how active galaxies differ observationally from normal galaxies and understand qualitatively the standard accreting black hole paradigm for active galactic nuclei (AGN)
 - ◇ understand the radiative transfer problem in the context of AGN line-emitting regions and quasar absorption lines.

Text and Reference Books

There is no set text book for this unit. Lecture notes will be available via WebCT. The following reference books may also be useful. They are available on closed reserve from the Physics Library.

- Bowers, R. and Deeming, T., 1984, *Astrophysics, Vols. I and II*
- Osterbrock, D. E., 1989, *Astrophysics of Gaseous Nebulae and Active Galactic Nuclei*
- Shu, F. H., 1982, *The Physical Universe*

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