PHAS3136 - Cosmology and Extragalactic Astronomy

Prerequisites

This is a 3rd-year ‘portmanteau’ course designed to provide both an introduction to basic cosmological principles and a summary of selected topics in extragalactic astronomy. The only pre-requisites are basic mathematical skills (i.e., elementary calculus) and general familiarity with astronomical nomenclature and principles. Students will not normally have encountered General Relativity at the time they take this course, and the development of the material is therefore essentially non-GR, although GR results are introduced as necessary. (A subsequent GR-based cosmology course is available from the Maths Dept.)

Aims of the Course

This course aims to:

- summarise the essential physics describing the evolution of the Universe;
- review the essential morphological, dynamical, and chemical properties of galaxies in the local Universe;
- introduce key ideas in the processes involved Active Galactic Nuclei.

Objectives

After completion of this course students should be able to:

- describe the gross characteristics of evolution of matter and radiation in the Universe, including the formation of the microwave background and of the light elements;
- discuss the role of inflation in resolving several problems with the traditional Big Bang model;
- describe how theory and observation lead to the inference of baryonic and non-baryonic dark matter on a variety of scales;
- explain the evolution of chemical abundances, colours, and luminosity in isolated galactic systems;
- state the basic techniques used for determining Galactic and galactic dynamics, and explain the inferences drawn from those data;
- describe a variety of techniques for estimating masses, and mass:light ratios, in clusters of galaxies;
- summarise the taxonomic ‘zoo’ of active galaxies, and describe how their diverse morphological characteristics can be understood in the context of a simple unified model;
- describe how the linear scales of broad-line systems can be estimated through reverberation mapping;
- explain the nature of the quasar luminosity function, how it evolves with time, and how selection effects can bias the results.

Methodology and Assessment

The course is based on 30 lectures plus 3 sessions which are used for reviewing homeworks and for supplementary material (summaries of important recent papers in the field, slides, etc.). There are 4 problem sheets, which include both essay work and calculation of numerical results for different cosmological models. Assessment is based on the results obtained in the final written examination (90%) and by 3 problem sheets (10%).

Textbooks:

The principal recommended book is:

- *An introduction to galaxies and cosmology* (Jones & Lambourne, Cambridge)

Additional recommended books are:

- *An Introduction to Modern Cosmology* (Liddle, Wiley)
- *An Introduction to Active Galactic Nuclei* (Peterson, CUP)

Syllabus

(The approximate allocation lectures to topics is shown in brackets below.)

Part I: Galaxies

Our galaxy, populations. Spiral structure; rotation curves (21 cm); mass distribution (dark matter). [4]

Morphology, luminosity function; Tully-Fisher & Faber-Jackson relations; mass-to-light ratios; fundamental plane. [1]

Galactic chemical evolution; the ‘G-dwarf problem’ and possible solutions [2]

Measurements of the Hubble Constant [1]

Clusters of galaxies. Morphology; mass indicators (Virial theorem, X-ray emission, gravitational lensing). [3]

Part II: Active Galactic Nuclei

Taxonomy and principal observational characteristics; the central engine (mass, luminosity, nature). [1]

The broad-line region; reverberation mapping. Broad and narrow absorption-line systems in quasars; Mass estimates. [2]

Gunn-Peterson test. Quasar luminosity function (survey techniques, selection effects); the logN – log S and V/Vmax tests. [1]

Part III: Cosmology

Introduction; the observational basis of cosmological models; a brief history of the Universe, from $t = 10^{-43}$s to the present. [2]

The Friedmann equation; evolution of density and scale factor with time (the fluid equation and acceleration equation). [3]

Derivation and meaning of the cosmological parameters.

Specific models (Einstein-de Sitter, Milne, etc.) [2]

Formation and evolution of the Cosmic Microwave Background (CMB); production of the light elements. Baryogenesis. [4]

Problems with the traditional Big Bang model (flatness, horizon, monopoles, structure); inflation; [1]

Large-scale structure and CMB power spectra. [3]