2018 Spring — PHYS 315 [8255]

Book: Peter Schneider Extragalactic astronomy and cosmology

**ISBN-13:** 978-3642540820  
**ISBN-10:** 3642540821

3 credits

Pre-requisites: PHYS122 or PHYS 122H with grade C or higher. A good grade in either PHYS 105 or PHYS 304 will be of some advantage, but not required.

Material: scientific calculator

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Course objectives: Main objectives are for students to become familiar with the characteristics and components of the various galaxy types in the known universe.

Detailed Objectives: By the end of the course students will be able to

- describe the various types of galaxies found in the universe  
- describe some of the observing techniques used in the study of galaxies  
- understand the components of our Galaxy, the Milky Way  
- understand the importance of supermassive black holes in galaxy nuclei  
- understand the importance of galaxy studies to cosmology

Grading:
Final Exam 20%  
2 Mid term Exams 20% each  
Telescope attendance 10%  
Class attendance 10%  
Homework 20%

The course will include (provisional topics, may be revised in the details):

- The Milky Way as a galaxy  
  o Galactic coordinates  
    o Determination of distances within our Galaxy  
      + Trigonometric parallax  
      + Proper motions  
      + Moving cluster parallax  
      + Photometric distance; extinction and reddening  
      + Spectroscopic distance  
      + Distances of visual binary stars
+ Distances of pulsating stars
o The structure of the Galaxy
  + The Galactic disk: Distribution of stars
  + The Galactic disk: chemical composition and age
  + The Galactic disk: dust and gas
  + Cosmic rays
  + The Galactic bulge
  + The visible halo
  + The distance to the Galactic center
o Kinematics of the Galaxy
  + Determination of the velocity of the Sun
  + The rotation curve of the Galaxy
o The Galactic microlensing effect: The quest for compact dark matter
  + The gravitational lensing effect I
  + Galactic microlensing effect
  + Surveys and results
  + Variations and extensions
o The Galactic center
  + Where is the Galactic center?
  + The central star cluster
  + A black hole in the center of the Milky Way
  + Flares from the Galactic center
  + The proper motion of Sgr A*
  + Hypervelocity stars in the Galaxy

The world of galaxies
o Classification
  + Morphological classification: The Hubble sequence
  + Other types of galaxies
o Elliptical galaxies
  + Classification
  + Brightness profile
  + Composition of elliptical galaxies
  + Dynamics of elliptical galaxies
  + Indicators of a complex evolution
o Spiral galaxies
  + Trends in the sequence of spirals
    + Brightness profile
  + Rotation curves and dark matter
  + Stellar populations and gas fraction
  + Spiral structure
  + Corona in spirals?
  + Scaling relations
    + The Tully-Fisher relation
    + The Faber-Jackson relation
    + The fundamental plane
    + The Dn-sigma relation
o Black holes in the centers of galaxies
  + The search for supermassive black holes
  + Examples for SMBHs in galaxies
  + Correlation between SMBH mass and galaxy properties
o Extragalactic distance determination
  + Distance of the LMC
  + The Cepheid distance
+ Secondary distance indicators
  o Luminosity function of galaxies
    + The Schechter luminosity function
    + The bimodal color distribution of galaxies
  o Galaxies as gravitational lenses
    + The gravitational lens effect - Part II
    + Simple models
    + Examples for gravitational lenses
    + Applications of the lens effect
  o Population synthesis
    + Model assumptions
    + Evolutionary tracks in the HRD; integrated spectrum
    + Star formation history and galaxy colors
    + Metallicity, dust, and HII regions
    + Summary
    + The spectra of galaxies
  o Chemical evolution of galaxies

Active galactic nuclei

  o Introduction
    + Brief history of AGNs
    + Fundamental properties of quasars
    + Quasars as radio sources: synchrotron radiation
    + Broad emission lines
  o AGN zoology
    + QSOs
    + Seyfert galaxies
    + Radio galaxies
    + OVVs
    + BL Lac objects
  o The central engine: a black hole
    + Why a black hole?
    + Accretion
    + Superluminal motion
    + Further arguments for SMBHs
    + A first mass estimate for the SMBH: the Eddington luminosity
  o Components of an AGN
    + The IR, optical, and UV-continuum
    + The broad emission lines
    + Narrow emission lines
    + X-ray emission
    + The host galaxy
    + The black hole mass in AGNs
  o Family relations of AGNs
    + Unified models
    + Beaming
    + Beaming on large scales
    + Jets at higher frequencies

Clusters and groups of galaxies

  * The Local Group
    o Phenomenology
* Mass estimate
  * Other components of the Local Group
* Galaxies in clusters and groups
  * The Abell catalog
  * Luminosity function of cluster galaxies
  * Morphological classification of clusters
  * Spatial distribution of galaxies
  * Dynamical mass of clusters
  * Additional remarks on cluster dynamics
  * Intergalactic stars in clusters of galaxies
  * Galaxy groups
  * The morphology-density relation
* X-ray radiation from clusters of galaxies
  * General properties of the X-ray radiation
  * Models of the X-ray emission
  * Cooling flows
  * The Sunyaev-Zeldovich effect
  * X-ray catalogs of clusters
* Scaling relations for clusters of galaxies
  * Mass-temperature relation
  * Mass-velocity dispersion relation
  * Mass-luminosity relation
  * Near-infrared luminosity as mass indicator
Clusters of galaxies as gravitational lenses

  * Luminous arcs
  * The weak gravitational lens effect