Syllabus for Astronomy 5830:
Observed Properties of Astronomical Systems

Autumn Semester 2017

Lectures: MWF, 8:50-10:20am, 4054 McPherson Lab

Professor: Paul Martini

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Course Web Page:

http://www.astronomy.ohio-state.edu/~martini/Astro5830/

Course Objectives

Astronomy 5830 is intended to provide an overview of observational astronomy at the introductory graduate level, with an emphasis on stars and galaxies. The topics we will cover include the basic properties of stars, quiescent and active galaxies, an overview of the properties of the Milky Way, and several other topics including the solar system, exoplanets, and clusters of galaxies. Throughout the course, we will emphasize how these properties are measured or inferred from astronomical observations. We will also cover observational techniques at various wavelengths.

Written Material

I will hand out detailed notes in advance of each lecture, and these notes, combined with some review articles and research articles, will be the primary written material for the course. You may find *Galactic Astronomy* by Binney & Merrifield (Princeton U. Press) and *Active Galactic Nuclei* by Peterson (Cambridge U. Press) are useful supplementary material, although I do not require that you to purchase either book.

Evaluation

The course grade will be based on homework (20%), a writing assignment and observing proposal (30%), class participation (30%), and a final exam (20%).

Homework Assignments

There will be four homework assignments. You may use any resource you wish except a person not in the class (you may work together or ask me, but not solicit outside help). Homework is due by **in class** on the following dates:

Homework 1: Sep 8
Homework 2: Sep 25
Homework 3: Oct 30
Homework 4: Dec 4

All late assignments will lose 10% credit per day, starting with after class time on the due date.

Writing Assignments

There will be one writing assignment. For this assignment you should survey the literature in a particular field of research (narrowly defined) and then write a summary of the main results, highlight the major unsolved questions, and discuss potential directions for future work. The writing assignment is intended to be similar to the written portion of the candidacy exam, although more modest in scope. This assignment is due in class on Oct 11.

Observing Proposal

The observing proposal is a proposal to obtain data to accomplish a science project of your choosing. It may be for any observing facility that you could reasonably get access to. The proposal should include an abstract (300 words or less), one page of scientific justification text written at an appropriate level for Ph.D. astronomers, but not specialists in the field, one page of technical justification, and up to two pages of figures, tables, and references. You should discuss your planned proposal with me and pick your topic by October 30. The proposal is due November 13 and should be submitted via email as a pdf file.

I will distribute the proposals to the class and a few others to grade, as well as grade them myself (we will collectively be the Time Allocation Committee or TAC). Your review of your classmates' proposals will be due November 27 and should take the form of a one-paragraph summary of each proposal's strengths and weaknesses. I will provide you with my feedback, as well as anonymous feedback from the rest of TAC.

Class Participation

The course materials will include various required reading assignments that will be on the class website. You will be assigned to lead a discussion of the highlights of several of these reading assignments during the semester. These should be 10-15 min presentations in the style of presentations at AstroCoffee.

Final Exam

The final exam will be a take-home exam with three questions. The exam will be closed book, closed notes, and could include any material we covered in the class. I do not expect you to have memorized complex equations, however you are expected to know simple scaling relationships. The final exam will be due on December 8.

Course Topics

These topics are only approximately what we will cover. Please see the class website for more current information.

Part I. Stars

Distances and Motions

- Coordinate systems
- Trigonometric parallaxes
- Proper motions, radial velocities, & true space motions
- Astrometric catalogs & future space missions

Masses and Radii

- Stellar masses
- Stellar radii

Spectral classification

- Historical overview and the modern MK system
- L, T, and Y dwarfs

- Luminosity classes
- Special classes of stars

Stellar Properties and Relationships

- Physical properties (T_{eff}, g, Z, L)
- Relations among stellar properties (H-R, M-L, M-R)
- Inferences from these relations

Stellar Photometry & Spectrophotometry

- Flux and calibration
- Filter systems
- Line blanketing and UV excess

Stellar Luminosity and Mass Function

- Calculation of the stellar LF
- Malmquist bias
- Solar neighborhood
- Initial mass function

Stellar Evolution in an Observational Context

- Evolution on the main sequence
- The fate of low-mass stars
- The fate of high-mass stars

Variability in Stars and Remnants

- The κ-mechanism
- Stars in the instability strip and P-L relations
- Baade-Wesselink distance method
- Basic Astroseismology

Part II. Observational Methods

Signal and Noise

- Imaging
- Spectroscopy
- Limiting Cases

Detection of Light

- Telescopes
- Instruments
- Detector Technology

Big Data

- Basic Considerations
- Software Tools

Part III. Solar System and Exoplanets

The Sun

- Chemical Composition
- Helioseismology

The Solar System

- Formation
- Planets, Dwarf Planets, and minor bodies
- Outer Solar System

Exoplanets

- Detection
- Demographics
- Properties
- Future prospects

Part IV. Milky Way

Interstellar Extinction

- Total & selective extinction, (A_V, R_V)
- The interstellar extinction curve
- Reddening vectors

Galactic Chemistry

- Origin of the elements (r-process and s-process)
- Metallicity of the Galaxy
- Chemical evolution

Stellar Systems and the Structure of the Milky Way

- Open and globular clusters
- Disk and halo
- Bulge and Galactic Center

Stellar Kinematics

- Solar motion (LSR, Solar Apex)
- Kinematics near the Sun
- Formation of the Galaxy (ELS, Searle & Zinn)

Part V. Galaxies

Morphological Classification of Galaxies

- Introduction
- Classification revisited
- Galaxies at other wavelengths

Surface Photometry

- Basic principles and practical issues
- Profiles in practice

Galaxy Luminosity Function

- Schechter function

- Passbands, brightness estimates, extinction, k-corrections
- Luminosity functions
- Quantities derived from the luminosity function

Properties of Elliptical Galaxies

- Correlations among global properties
- Other spheroidal systems

Properties of Disk Galaxies

- Classification of spirals
- Bars, rings, pseudobulges
- Tully-Fisher relation

Groups and Clusters

- Classification of clusters
- Galaxies within clusters
- Cluster masses and scaling relations

The Local Group

- Overview
- Tidal streams
- Cosmochemistry

ISM in Galaxies

- Overview of the ISM (HI, H_2, HII, hot ISM)
- Observations of the ISM in galaxies
- Distribution within disk galaxies
- Dust in galaxies

Star Formation

- Diagnostics
- Star formation in disk galaxies
- Regulation of SF (Schmidt & Kennicutt Laws)
- Evolution of the cosmic SFR

Galaxy Evolution

- Star Formation Rate
- Mass-Metallicity Relation

Part VI. Active Galactic Nuclei

AGN Taxonomy

- LINERs, Seyferts, and QSOs
- Radio Galaxies
- Type I and Type II

Physical Processes in AGN

- Blackbody emission

- Synchrotron radiation
- Inverse Compton

Eddington Limit and Black Hole Growth

- Radiation Pressure
- Radiative Efficiency
- Accretion rate

Accretion Processes

- Shakura-Sunyaev Disk
- ADAFs

Broad Line Region

- Physical Conditions
- Geometry

Reverberation Mapping

- Isodelay surfaces and transfer function
- Geometry
- Radius-Luminosity Relation

Narrow Line Region

- Physical Conditions
- Structure, spatial extent, and ionization cones

Unification

- Torus
- Obscuration

AGN Luminosity Function

- Wavelength dependence
- Evolution

Co-evolution of Black Holes and Galaxies

- Black Hole – Host Galaxy Relations
- Space density and evolution
- Growth timescales