

ASTR680 *High Energy Astrophysics* (Spring 2015)

Introduction and Syllabus

**Instructor:**

Prof. Suvi Gezari

Office: PSC 1201

Phone: 301-405-6651

Email: suvi@astro.umd.edu

**General Course Description:** This course will cover the astrophysics of compact objects (white dwarfs, neutron stars, black holes), accretion and jet physics, supermassive black holes, energetic transients (supernovae, gamma-ray bursts, tidal disruption events), as well as multi-messenger (non-photon) astronomical sources (cosmic rays, neutrinos, gravitational waves). These are some of the most exotic and powerful phenomena in the Universe. Their physics is extreme, and requires the understanding of the interaction of matter and high-energy radiation, strong gravitational fields, and strong magnetic fields. This course will survey both our theoretical understanding and modern observational view of these objects.

**Schedule:**

*Lectures:* Tue and Thu from 12:30pm to 1:45pm in room CSS 0201

*Midterm Exam:* during class on Tuesday, March 24, 2015

*Final Exam:* 1:30am to 3:30pm, Tuesday, May 19, 2015

**Book:** "High Energy Astrophysics" by Malcolm S. Longair, Third Edition

**Grading Policy:** Grades will be based on weekly reading assignments, problem sets, class participation, an individual class project, and the midterm and final exams. The proportion of the final grade for each of these components is:

|                            |     |
|----------------------------|-----|
| <i>Weekly Reading</i>      | 10% |
| <i>Problem Sets</i>        | 10% |
| <i>Class Participation</i> | 5%  |
| <i>Midterm Exam</i>        | 25% |
| <i>Final Exam</i>          | 35% |
| <i>Individual Project</i>  | 15% |

**Late Policy and Make-Up Exams:** Partial credit for late problem sets may be obtained if you give me a valid reason *prior to the due date* of the problem set. No credit will be given for problem sets turned in *more than one week* after the due date. No late key plot summaries will be accepted. If you

cannot make the midterm or final exams, tell me prior to the exam date and we can schedule an alternative. To be fair to other students, any make-up exam will be given *before* the scheduled date unless this is not possible due to illness.

**Weekly Reading Assignment:** Each Tuesday I will be assigning a key paper in the subject area of that week's lectures. Your assignment is to:

- Read the paper.
- Identify the **key plot** in the paper.
- Write a **summary** of this plot.
- **Lead** (at most twice) a discussion of the key plot with the class.

The written plot summaries are worth 10% of your grade (for a total of 10 assignments), and are due at the *beginning* of the next Tuesday's lecture. Your summary should include the context and motivation of the plot, a description of the plot itself, how the values on the plot were determined, including a description of what theoretical models or equations were used, and the important conclusions learned from the plot. The length and style should be similar to the blog "Astroplots" at [astrobites.tumblr.com](http://astrobites.tumblr.com), but with the addition of equations and model descriptions. You should feel free to discuss the weekly reading assignment with your classmates, but you must write up your key plot summary in *your own words*.

I will randomly pick a name each Tuesday to lead the discussion of the key plot with the class. If you have presented twice, your name will be removed from the drawing. Both your participation as a leader *and* your participation during class discussion will count towards your class participation grade, which is worth 5% of your overall grade.

**Problem Sets:** You will have two problem sets, one in preparation for the midterm, and one in preparation for the final. These problem sets will count towards 10% of your final grade.

**Individual Class Project:** Approximately 15% of the grade will be based on an individual project. Information on this project will be distributed some time before the midterm exam.

**Midterm and Final Exam:** The exams will include key plot summaries as well as problems similar to the problem sets assigned for homework.

## **Syllabus:**

### **I. Compact Objects [Weeks 1-3]**

#### ***White Dwarfs***

e<sup>-</sup> degeneracy pressure, equation of state, mass-radius relation

#### ***Neutron Stars***

structure, radio pulsars, dP/dt vs. P diagram, binary pulsars

#### ***Black Holes***

Schwarzschild metric, Kerr metric, X-ray binaries, microquasars

### **II. Accretion [Weeks 4-5]**

#### ***Accretion Theory***

spherical accretion, thin disk, thick disk, Roche-lobe overflow

#### ***Accretion-powered Binary Systems***

binary stars, CVs, novae, LMXBs, HMXBs

### **III. Supermassive Black Holes [Weeks 6-7]**

#### ***Active Galaxies and Relativistic Jets***

quasars, Seyfert galaxies, radio-loud AGNs, blazars

#### ***Dormant SMBHs***

dynamical mass measurements,  $M_{\text{BH}}-\sigma$  relation and galaxy formation

### **SPRING BREAK [Week 8]**

### **MIDTERM EXAM [March 24, 2013]**

### **IV. Energetic Transients [Weeks 9-11]**

#### ***Supernovae***

Ia, core-collapse, ultraluminous, pair-instability

#### ***Gamma-ray Bursts***

#### ***Tidal Disruption Events***

### **V. Multi-messenger Astronomy [Weeks 12-13]**

#### ***Cosmic Rays***

#### ***Neutrinos***

#### ***Gravitational Waves***

### **VI. Current High Energy Telescopes [Week 14]**

***Gamma Ray:*** Swift, Fermi, Agile, HAWC

***X-ray:*** Chandra, XMM-Newton, Suzaku, Integral, MAXI, NuSTAR, Astro-H

***Cosmic Rays:*** Auger, ***Neutrinos:*** IceCube, ***Gravitational Waves:*** LIGO

### **VIII. Class Projects [Weeks 15-16]**

### **FINAL EXAM [May 19, 2015]**