

AST 7939, section # 3574: High Energy Astrophysics, Spring 2008

Asst. Prof. Jonathan Tan

Monday periods 8 and 9 (3:00-4:55pm), Wednesday period 6 (12:50-1:40pm); Room 3, Bryant

This is a one semester lecture course on the broad field of High Energy Astrophysics. There is no required textbook, however you will find “Introduction to High-Energy Astrophysics” by Rosswog and Brügger and “Accretion Power in Astrophysics” by J. Frank, A. King and D. Raine to be very useful. Also recommended are volumes 1 and 2 of “High Energy Astrophysics” by M. S. Longair. All these books are published by Cambridge University Press.

My office is 302 Bryant and my office hours are immediately after the one-hour class period, i.e. Wed 1.40pm, or by appointment. I can also be reached at 352 392 2052 ext. 254, or (best) by email at jt @ astro.ufl.edu. The website for the class is at www.astro.ufl/~jt/teaching/he/index.html.

Your final grade will be determined by your homework (50%), oral presentations (20%), and research/review project (30%).

During the semester, each student registered in the class will give a short oral presentation on a High Energy Astrophysics research topic (see list below, or talk to me about other possible topics). This first talk is meant to be an exploratory mini review of a current active research topic - basically summarizing a few key papers. At the end of the semester, in lieu of a final exam, students will prepare a term paper (usually on the same subject) (max. 10 pages) that goes into more detail, and may include some original analysis or calculations. This will be the basis for a final oral presentation, which will be scheduled in or around the last week of classes.

We will aim to have the short oral presentations once a week during the Wednesday period, combined with a discussion of recent papers and preprints relevant to high energy astrophysics.

Detailed Syllabus

1. What is high-energy astrophysics: An overview
2. The Physics of Spherical Accretion
 - (a) Quasars and the need for efficient energy release. The Eddington Limit.
 - (b) Steady Spherically Symmetric Accretion: the Bondi Accretion Rate.
 - (c) Bondi-Hoyle Accretion.
 - (d) Electron-proton coupling, two-temperature radiatively inefficient accretion flows; application to Galactic center and other supermassive black holes.
3. Accretion Disks
 - (a) The role of angular momentum. Viscous transport of angular momentum.
 - (b) The simple thin disk model.
 - (c) Thermal spectrum.
 - (d) Comparison to observations.

(e) Outflows from accretion disks.

4. Accretion in Binaries

- (a) Overview of Stellar Structure and Evolution: Origin of Compact Objects.
- (b) Tidal Radius and Disruption of Stars in AGN.
- (c) The Roche Radius, Conservative Mass Transfer and Effects on the Orbital Elements.
- (d) Unstable mass transfer; common envelopes, origin of CVs.
- (e) Control of \dot{M} by gravitational radiation, magnetic braking and/or stellar evolution.
- (f) Disk formation and the circularization radius.
- (g) Thermal instabilities in accretion disks.
- (h) Overview of accreting binary systems.

5. Sudden thermonuclear energy release

- (a) Thermonuclear burning on white dwarfs.
- (b) Type Ia supernovae.
- (c) Combustion fronts, Deflagration versus Detonation, Rayleigh-Taylor Instabilities.
- (d) Type II supernovae.

6. Non-Thermal Processes

- (a) Galactic Non-Thermal Radio Emission: Synchrotron radiation.
- (b) Gamma-Ray emission from the Galactic Plane.
- (c) Cosmic Rays.
- (d) Pulsars.

7. Relativistic Jets and Gamma-Ray Bursts

- (a) “Superluminal” motion in radio jets.
- (b) Jets from AGN: Blazars; non-thermal emission.
- (c) Overview of observational characteristics of GRBs.
- (d) Models of GRBs. Relativistic fireballs.

Research/Oral Presentation Topics

The following list is not meant to be exhaustive. If you have ideas for other topics, please discuss them with me.

Critical review of evidence for intermediate mass black holes, particularly from ULXs.

The Origin of Ultra-High Energy Cosmic Rays.

The Origin of Short Period GRBs.

The Origin of Long Period GRBs.

Gamma-Ray Emission from the Galactic Center as possible evidence for Dark Matter.

Evidence for the Existence of Quark Stars?

Methods and uncertainties of estimating supermassive black hole masses.

Formation mechanisms of Supermassive Black Holes.

Type II supernova explosions: exploding a star via core collapse.

Can dust be produced in supernovae?

Pair Instability Supernovae.

The cosmic-ray energy budget in individual supernovae.