Physics/Astronomy 442 High Energy Astrophysics and Radiative Processes

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Overview: This is an advanced undergraduate-level course on some of the most energetic objects and phenomena in the universe. Examples are supernovae, gamma ray bursts, and neutron stars and black holes that are accreting matter from their surroundings. Most of what we know about such objects comes from the study of X-ray and gamma-ray photons arriving at Earth. Some information also arrives in the form of energetic elementary particles — cosmic rays. The processes that produce these energetic photons and particles are often non-thermal, *i.e.*, the spectrum is far from that of a black body, so we will need to study these processes in order to deduce the properties of the source from the emitted spectrum. We will also study how X-rays and gamma-rays are detected.

High energy astrophysics is a very active area of astronomy today, with at least eight orbiting observatories in operation. As part of the class, you will analyze data from some current and past satellites.

Lectures: Tuesday and Thursday, 4th period (1:40 - 3:00 PM for classes on Busch Campus), ARC 205.

Home page: http://www.physics.rutgers.edu/ugrad/442/

Text: *Introduction to High Energy Astrophysics*, S. Rosswog & M. Brüggen, Cambridge University Press, ISBN 978-0-521-85769-7). This is a good, up-to-date introduction to the field at the advanced undergraduate level. Its main weakness is sparse coverage of how X-rays and gamma-rays are detected and I will provide supplementary material on that topic and the existing ground-based and satellite observatories. Rather than progressing directly through the text, we will start with Chapter 4 on supernovae and skip back to earlier chapters to introduce physical processes as they are needed.

Other texts that could be useful as reference material are listed below. The first four of the books are on reserve at the Physics Library.
Exploring the X-ray Universe, P. A. Charles & F. D. Seward, 1995, Cambridge University Press (undergraduate-level survey of x-ray astronomy; out of print and somewhat out of date, though still a good introduction to many topics)
Foundations of High-Energy Astrophysics, M. Vietri, 2008, Univ. Chicago Press (a graduate-level textbook, though it often begins with an insightful physical discussion)
High Energy Astrophysics, Vols. 1 & 2, M. S. Longair, 1992/1994, Cambridge University

Press (graduate textbook; somewhat quirky in organization; becoming somewhat out of date, though has thorough discussions of the important physical processes)
Radiative Processes in Astrophysics, G. B. Rybicki & A. P. Lightman, 1979, Wiley (advanced undergraduate/graduate text, probably the best introduction to the processes which produce electromagnetic radiation and are important in astronomy)

An Introduction to Modern Astrophysics, B. W. Carroll & D. A. Ostlie, 1996, Addison-Wesley (a somewhat lower-level — Ph 341/342 — survey of astronomy; useful for background material)
High Energy Astrophysics, F. Melia, 2009, Princeton Univ. Press (advanced undergraduates and graduate students; covers only accretion and not shocks; it does treat observations and detectors) *Astronomy Methods, A Physical Approach to Astronomical Observations*, H. Bradt, 2004, Cambridge Univ. Press (an advanced undergraduate text, focusing on observing methods; has a significant amount of material on X-ray, gamma-ray, and neutrino astronomy)

Active Galactic Nuclei, J. H. Krolik, 1998, Princeton Univ. Press (graduate text, though the "phenomenology track" should be understandable to undergraduates)
Accretion Power in Astrophysics, 3^{rd} edition, Frank, King, & Raine, 2002, Cambridge Univ. Press (graduate text)
Very High Energy Gamma Ray Astronomy, T. C. Weekes, 2003, Institute of Physics (graduate text; a very readable introduction to the field and many parts are accessible to undergraduates)

Office hours: 2:00 - 4:00 PM, Wednesday; call or email to arrange other times.

Homework and Grades: Your grade will be based on about seven problems sets (70%) and about two projects involving the analysis of data (30%). The problem sets will be handed out one week and due the next. You will have more time for the projects. Please let me know in advance if you will not be able to turn in an assignment by the due date. Assignments handed in after I have returned the graded papers will not receive credit. You may discuss the assignments with your classmates, but your written work must be substantially your own. If you are having difficulty with a question, I encourage you to talk to me about it.

Students with Disabilities: If you have a disability, you are urged to speak to me early in the semester to make the necessary arrangements to support a successful learning experience. Students with disabilities should consult the webpage:
http://www.physics.rutgers.edu/ugrad/disabilities.html.