High Energy Astrophysics

Instructor: W-Y. Pauchy Hwang

Fall Semester 2010

Every Monday Morning, except those few dates when I travel abroad.

Chapter 0: What can we learn in "High Energy Astrophysics" - in 2010 ? (in 2 or 3 lectures.)

§. 0.1. It goes beyond the optical/infrared (OIR) astronomy.

A conventional way to define an astronomy is through the wavelengths employed by the observing instruments - the optical/infrared (OIR) astronomy through the optical telescope with infrared imaging instruments, radio astronomy through detection of radio waves, X-ray astronomy through X-rays, gamma-ray astronomy through the observation of gamma rays, and so on. However, the farther away the original signals, the much weaker the signals which can be detected - through both inverse square distance laws and the red-shifting. A very high energy astrophysical phenomenon, the higher in energy the more likely to occur much farther away, could look quite ordinary from the earthling's point of view.

§. 0.2. It is a study of astrophysical phenomena of high energy in origin.

The high energy processes in astrophysics include, for example, supernova explosions, gamma ray bursts, formation of black holes, collisions of compact stellar objects, accretion disk and jets around supermassive black holes, ultra high energy cosmic rays, and even the hot big bang or the inflation.

It follows by a power-point presentation entitled "What can We Learn by High Energy Astrophysics - in 2010?".

Chapter 1: Glimpse on Thermodynamics

§. 1.1. Preliminaries

§. 1.2. The First Law of Thermodynamics

§. **5.3. Rotating Black Holes**

§. **5.4. Search for Stellar Black Holes**

Chapter 6: Ultra High Energy Cosmic Rays

§. **6.1. The Other Limits**

§. **6.2. TeV or PeV High Energy Physics**

§. **6.3. Search for Exotic Particles**

Chapter 7: Cosmology as an Experimental Science

§. **7.1. Robertson-Walker Metric**

§. **7.2. The Hot Big Bang**

§. **7.3. Baryogenesis and Matter-Antimatter Asymmetry**

§. **7.4. Big-Bang Nucleo-synthesis (BBN)**

Chapter 8: Epilogue

§. **8.1. Missing Items: Gravitational Waves, Cosmic Defects, and other Exotics**

§. **8.2. What is Dark Matter?**

§. **8.3. What is the Nature of Dark Energy?**

References

http://imagine.gsfc.nasa.gov/docs/science, Laboratory for High Energy Astrophysics, NASA, U.S.A.

Malcolm S. Longair, *High Energy Astrophysics: Volume 2. Stars, the Galaxy and the interstellar medium*, Second Edition (Cambridge University Press, 1997 and 2000).

Jonathan I. Katz, *High Energy Astrophysics* (Addison-Wiley, Menlo Park, CA, 1987).

Valeri P. Frorov and Igor D. Novikov, *Black Hole Physics* (Kluwer Academic Publishers, 1998).

Edwin F. Taylor and John Archibald Wheeler, *Exploring Black Holes - Introduction to General Relativity* (Addison-Wesley Longman, Inc., 2000).

2007 International Symposium on Cosmology and Particle Astrophysics, *Modern Physics Letters A*, Vol. 23, No. 17-20, June 28, 2008 (Eds. W-Y. Pauchy Hwang, Xiao-Gang He, and Kin-Wang Ng).

Kerson Huang, *Statistical Mechanics* (John Wiley & Sons, New York, 1963 & 1987), on Chapter 1 and statistical mechanics.

Requirements

The course "High Energy Astrophysics" is intended as a core graduate course in Taida's Institute of Astrophysics. In other words, it should offer important physical concepts, including thermodynamics, statistical mechanics, general relativity, quantum field theory, and so on, while furnishing the various calculation schemes/techniques. Of course, certain topics such as gamma ray bursts, black holes, ultra high energy cosmic rays, neutrino astronomy, and cosmology should be suitably covered. The breath and depth depends on the personal taste.

I would suggest the following requirements:

a term paper - based on Chapter 0 - due on the middle of the semester, say, November 8, 2010 (20%); plus,

Homework Problems of Chapters 1-7 (40%); plus,

a final exam. (40%)

I hope that you have good luck in learning !!