Ph237a/236b: Genera Relativity/Gravitational Waves (theory)

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Winter 2008

1 Course Description

This is the second term of Ph236, *General Relativity*, and the first term of Ph237, *Gravitational Waves*. In this course, we will:

- Use general relativity to analyze sources of gravitational waves, and in this process learn more about general relativity than already taught in Ph236a.
- Study astrophysics and cosmology, and understand how (and how often) various types of gravitational-wave events can take place in the real universe. [1]
- Understand how detector data can be analyzed to optimize our chance for detection, and to extract physical information about the sources and in some occasions about the universe the waves propagate through.

In the next term (Spring 2008), in Ph237b, we will

- Explore the principles of (ground based and space based) gravitational wave detectors
- Learn what limits the sensitivities of real detectors
- Develop designs for the next generation of detectors.

Ph237b is different from Ph236c, which will be taught by Kip Thorne and Lee Lindblom, and will deal with more theoretical aspects of general relativity. These two follow-up courses will not clash with each other in time, so it will be possible to take both of them.

2 Textbooks and Reading Materials

Reading materials of Ph236 will still be useful for part of this term, namely

- Misner, Thorne and Wheeler, *Gravitation*
- Wald, *General Relativity*
- Hartle, *Gravity: An Introduction to General Relativity*
- Schutz, *A First Course in General Relativity*
- Carroll, *Spacetime and Geometry*

[1] In Ph237ab, we will also study how to artificially generate a detectable source of gravitational waves — but that seems nearly impossible.

- Blandford and Thorne, *Applications of Classical Physics*, available online at the course website of Ph136, *http://www.pma.caltech.edu/Courses/ph136/yr2006/*

Please refer to Ph236a's Course Description for detailed comments on these books. There are very few textbooks specifically about gravitational waves, here we list two of them:

- Peter R. Saulson, *Fundamentals of Interferometric Gravitational Wave Detectors,* World Scientific, 1994. This book covers concisely many aspects of interferometric gravitational wave detectors, and will be a good reference for Ph237b. It does not cover enough details about sources as we would like in this term. [2]

- Michele Maggiore, *Gravitational Waves, Volume 1: Theory and Experiments,* Oxford, 2007. [3] Despite the title, this book is really mostly about theory and data analysis with idealized Gaussian noises: the part on instruments is too short and sometimes misleading. The theory part is mostly about analyzing inspirals of non-spinning compact binaries. As a consequence, the book will only be relevant for about 1/4 of this term. Nevertheless, this book might contain detailed solutions to homework problems we will assign — in that case you are required not to consult with those solutions before you turn in your own.

We will give recommended reading materials each week together with the homework. Much of the material will be available at a password-protected portion of the course website.

3 Instructors and TAs

Instructors of this course will be Rana Adhikari and Yanbei Chen. Here are our contact informations:

- *Rana:* rana AT caltech.edu, 254 W. Bridge, ext: 8709

- *Yanbei:* email, *yanbei AT caltech.edu*; office, 129 Bridge Annex; extension, 4258.

4 Grading and Homework

Homework problems, together with suggested/recommended reading, will be put onto the course website each Wednesday evening, and will be due before class the following Wednesday. Late homework will *not* be accepted unless prior arrangements have been made with a TA — or, at minimum, a request for an extension has been e-mailed to the TA before the due time, and the TA deems the justification for lateness acceptable. In order to obtain an extension, you *must have a compellingly legitimate reason,* such as illness or travel in connection with research. Any homework extensions longer than one week must be approved in advance by one of the instructors.

Solutions to the homework will be put onto the course website Wednesday evening. Many of the same problems have been used in previous years; for them there are many copies of solutions on campus. *You are not allowed to consult those solutions until after turning in your own homework.* We take very seriously this rule and enforce it under the Caltech honor system. On the other hand, *you are encouraged to discuss the problems with each other, while you are trying to solve them,* with the proviso that *after the discussions you must write up your solutions yourself, independently of anyone else.*

Graded problem sets will be available for pick up at class the following Wednesday. After class they will be placed on a shelf marked "Ph236a/237b" in the Theoretical Astrophysics Interaction Room [124 Bridge Annex].

[2] According to the author there is *not* a more advanced version in the works

[3] According to the author, Volume 2 will be about astrophysical and cosmological sources, and is currently in preparation. He expects to complete it in a few more years.

This course will be Pass/Fail by default. Students who wish to switch to the ABCDF system can do so by petition through the registrar's office, plus personal arrangement with the instructors. The course grade will be based on homework and an optional final exam in the following manner.

- Students who score 60% or more will pass without having to take the final.
- Without taking the final, students graded ABCDF will be graded A if their homework score above 90%, B if between 75% and 90%, C if between 60% and 75%, and F if below 60%.
- Students who wish to improve their grades (e.g., those who would fail based on their homework scores) can attempt to do so by taking the final exam.