PHYSICS 600: Introduction to Gravitational Wave Detection

Syllabus, Fall 2019

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**Overview**

Gravitational waves were predicted in 1916; the first detection of gravitational waves was announced in 2016. Clearly, there’s a story there. This course is aimed at illuminating that story.

The story involves decades of doubt that gravitational waves could even exist, decades of implausible claims that they had been detected, and then decades of waiting for sufficiently sensitive detectors to be developed to allow the waves to be seen.

The course will focus on the measurement challenge and how it has been met. We’ll study some of the classic papers on the measurement technology necessary to detect gravitational waves, as well as some of the most up-to-date accounts of what new technology is required for the field to progress in the future.

**Course work**

The course will meet in Physics Building Room 208 on Mondays and Wednesdays, from 12:45 to 2:05 p.m. All students should register for 3 credits.

For the most part, the course will function like a guided “journal club”. For every class, there will be an article (or other reading, like a book chapter), that students will read in advance. Each student will be responsible for bringing at least one good question on the assigned reading to each class. Students will take turns leading the discussion of the articles, with the aim of making clear its central idea of importance to the making of a sensitive gravitational wave detector.

Each student will also complete a term project focused on a detector subsystem of their choice.

Active student engagement (reading, posing questions, leading and engaging in discussions) is the central work for the course and will be the basis of the grade. There will be no exams in this course.

Most readings will be supplied, but it is recommended that students have access to a copy of my *Fundamentals of Interferometric Gravitational Wave Detectors*, as well as to the new two-volume *Advanced Interferometric Gravitational-Wave Detectors* by Reitze et al.

**Topics**

* What are gravitational waves, and how might they be detected in principle?

Pirani (1957)

* Principles of sensitive measurement.

Dicke (1964), Michelson (1887), Hertz (1880s)

* The invention of practicable gravitational wave detectors

Weber (1960s), Weiss (1972), Drever (1980s, ‘90s)

* Sources of gravitational waves

Clark (1979)

* Key noise sources and how to make them small
  + shot noise and radiation pressure noise
  + thermal noise
  + seismic noise
  + Newtonian gravitational noise
* Key technologies
  + pre-stabilized lasers and optical cavities
  + suspensions
  + mirror coatings
  + servomechanisms
  + large high vacuum systems
* Design of interferometers

LIGO construction proposal (1989), Advanced LIGO White Paper (1999), Einstein Telescope Design Document (2011), Cosmic Explorer (2017)

* Space-based detectors, esp. LISA

**Syracuse University Policies:** Syracuse University has a variety of other policies designed to guarantee that students live and study in a community respectful of their needs and those of fellow students. Some of the most important of these concern:

**Diversity and Disability** (ensuring that students are aware of their rights and responsibilities in a diverse, inclusive, accessible, bias-free campus community) can be found here, at: <https://www.syracuse.edu/life/accessibilitydiversity/>.

**Religious Observances Notification and Policy** (steps to follow to request accommodations for the observance of religious holidays) can be found here, at: <http://supolicies.syr.edu/studs/religious_observance.htm>

**Orange SUccess** (tools to access a variety of SU resources, including ways to communicate with advisors and faculty members) can be found here, at: <http://orangesuccess.syr.edu/getting-started-2/>

**Disability-Related Accommodations:**

Syracuse University values diversity and inclusion; we are committed to a climate of mutual respect and full participation. There may be aspects of the instruction or design of this course that result in barriers to your inclusion and full participation in this course. I invite any student to meet with me to discuss strategies and/or accommodations (academic adjustments) that may be essential to your success and to collaborate with the Office of Disability Services (ODS) in this process.

If you would like to discuss disability-accommodations or register with ODS, please visit their website at http://disabilityservices.syr.edu. Please call (315) 443-4498 or email disabilityservices@syr.edu for more detailed information.

ODS is responsible for coordinating disability-related academic accommodations and will work with the student to develop an access plan. Since academic accommodations may require early planning and generally are not provided retroactively, please contact ODS as soon as possible to begin this process.

**Academic Integrity Policy:**

Syracuse University’s Academic Integrity Policy reflects the high value that we, as a university community, place on honesty in academic work. The policy defines our expectations for academic honesty and holds students accountable for the integrity of all work they submit. Students should understand that it is their responsibility to learn about course-specific expectations, as well as about university-wide academic integrity expectations. The policy governs appropriate citation and use of sources, the integrity of work submitted in exams and assignments, and the veracity of signatures on attendance sheets and other verification of participation in class activities. The policy also prohibits students from submitting the same work in more than one class without receiving written authorization in advance from both instructors. Under the policy, students found in violation are subject to grade sanctions determined by the course instructor and nongrade sanctions determined by the School or College where the course is offered as described in the Violation and Sanction Classification Rubric. SU students are required to read an online summary of the University’s academic integrity expectations and provide an electronic signature agreeing to abide by them twice a year during pre-term check-in on MySlice.