Seminar: Gravitational Waves

Instructor: Gabriela González

Topics:

1- Basic theory:

Linearized GR and  gravitational waves

History of understanding gravitational waves as a "real effect"

Effects of gravitational waves

2- Gravitational Wave detectors:

Basic useful concepts: Optical cavities, Michelson interferometer, Heterodyne/homodyne readout, Control systems (feedback and feedforward), System Diagnosis with measurements (Linear systems frequency response, noise spectral densities, coherence, signal-to-noise, …)

Power recycled Fabry-Perot interferometer (initial LIGO): optical configuration, control system, noise budget

Dual-recycled Fabry-Perot interferometer (advanced LIGO): optical configuration, control system, noise budget

Space based detector (LISA)

Pulsar timing

Resonant mass detectors

3- Sources of GWs and data analysis

Basic techniques: Matched filtering, wavelet analysis, cross-correlation.

Binary systems : neutron stars, black holes, white dwarfs

Sources of GW Transients: gamma ray bursts, core-collapse supernovas, star quakes, pulsar glitches, cosmic string cusps, …

Continuous, periodic sources

Continuous, stochastic sources

LIGO Scientific Collaboration results

Prospects for detection

Multi-messenger astronomy

The basic reference book will be

Gravitational-Wave Physics and Astronomy: An Introduction to Theory, Experiment and Data Analysis (Wiley Series in Cosmology)

Jolien D. E. Creighton, Warren G. Anderson

I will also use

Fundamentals of Interferometric Gravitational Wave Detectors, Peter R. Saulson

World Scientific Pub Co Inc (November 1994)

(Don't try to buy this book in Amazon, use http://www.worldscientific.com/ instead).

Preliminary schedule:

Starred dates are dates in which the class may be either held remotely or by another instructor (assuming classes are on Mondays).

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| --- | --- | --- |
| Week | Date | Topic |
| 1 | Jan 22 | Basic theory |
| 2 | Jan 28 | Basic theory |
| 3 | Feb 4 | GW detectors |
| 4 | Feb 11 | GW detectors |
| 5 | \* Feb 18 | GW detectors |
| 6 | Feb 25 | GW detectors |
| 7 | Mar 4 | GW detectors |
| 8 | Mar 11 | GW detectors |
| 9 | \* Mar 18 | GW sources and DA |
| 10 | Mar 25 | GW sources and DA |
|  | (Apr 1 - Spring break) |  |
| 11 | Apr 8 | GW sources and DA |
| 12 | \* Apr 15 | GW sources and DA |
| 13 | Apr 22 | GW sources and DA |
| 14 | Apr 29 | GW sources and DA |
| 15 | May 6 | GW sources and DA |

For registered students, there will be 3-5 short homework sets (1 or 2 problems or questions each), and a final report required on a reference chosen from a set list.