

重力波天文学 Gravitational Wave Astronomy

科目コード(Course Number) 20DASe12
物理科学研究科 School of Physical Sciences 天文科学専攻
Department of Astronomical Science 共通基礎 Common Base
学年(Recommended Grade) 1年 2年 3年 4年 5年
2単位(credit) 前学期 1st semester
Leonardi, Matteo

〔授業の概要 Outline〕

With the first detection of gravitational waves in 2015 the field of gravitational wave astronomy was born. After the first detection of a binary black hole coalescence, many others followed and, in summer 2017, gravitational waves coming from a binary neutron star merger were detected. This last detection is of paramount importance since it was accompanied by many detection of this phenomenon in the EM (visible, IR and gamma ray) spectrum.

The class will first introduce the theory of gravitational wave, then describe in detail the gravitational wave detectors and their performances and finally present the recent gravitational wave detections and the future perspectives.

〔到達目標 Aim〕

The aim of this class is to give to the students an overview of gravitational waves theory, detectors and detections.

At the end of the class, the student are supposed to know what is a gravitational wave and how it can be generated, how to detect them on Earth and which are the challenges about detecting them, which is the present status of the detections and which are their astrophysical and cosmological implications.

〔成績評価 Grading criteria〕

60% for attendance and 40% for the final report

〔授業計画 Lecture plan〕

- 第 1 回 Special relativity
Introduction to special relativity
- 第 2 回 General relativity
Introduction to general relativity
- 第 3 回 Linearization of Einstein equation
Geometric approach: linearization and TT-gauge
- 第 4 回 Gravitational waves in general relativity
Gravitational wave (GW) effect: interaction with test masses and with elastic body
- 第 5 回 GW sources (1)
Quadrupole approximation
- 第 6 回 GW sources (2)
Binary systems emission
- 第 7 回 GW sources (3)
Rotating rigid bodies emission
- 第 8 回 History of GW detectors up to now
Hulse-Taylor pulsar, resonant bars, GW interferometers (ITFs) introduction
- 第 9 回 GW interferometers
Fundamentals of laser optics, basic principle, sensitivity, response to GW
- 第 10 回 GW ITFs: quantum noise

Analysis of quantum noise limits for GW detectors and how to beat it

- 第 11 回 GW ITFs: thermal noise and other noises
Analysis of thermal and seismic noise limits for GW detectors
- 第 12 回 GW ITFs network
Gravitational wave detectors network and future experiments
- 第 13 回 GW detections: BBH
Gravitational wave detections from binary black holes mergers
- 第 14 回 GW detections: BNS
Gravitational wave detection from binary neutron star merger and multi-messenger astronomy
- 第 15 回 GW detections implications
Test of GR and astrophysical implications

〔実施場所 Location〕

NAOJ Mitaka Campus

〔使用言語 Language〕

English

〔教科書・参考図書 Textbooks and references〕

"Gravitational-Wave Physics and Astronomy"; Jolien D.E. Creighton, Warren G. Anderson; Wiley-VCH

"Fundamentals of Interferometric Gravitational Wave Detectors"; Peter R. Saulson; World Scientific

"Gravitational Waves - Volume 1: Theory and Experiments"; Michele Maggiore; Oxford

〔関連URL Related URL〕

URL:

〔上記URLの説明 Explanatory Note on above URL〕

〔備考・キーワード Others/Keyword〕