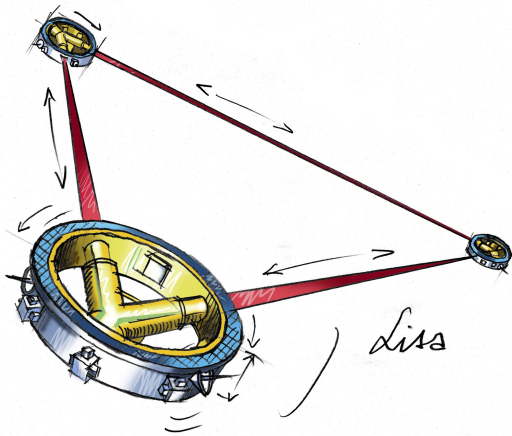




LISA data analysis



SUMMARY.

This METEOR will be dedicated to data analysis for the Laser Interferometer Space Antenna (LISA) – a space-based gravitational-wave detector that is planned to be launched in the mid-2030s.

We will study methods for LISA data analysis, focusing on techniques for signal detection and Bayesian parameter estimation. We will explore approaches ranging from classical Markov chain Monte Carlo (MCMC) methods to modern machine-learning techniques.

The theoretical part of the course will include a brief introduction to the construction of gravitational-wave waveforms for LISA as solutions to the field equations of general relativity. It will also cover probability theory and signal processing, as well as provide an overview of machine-learning techniques, including common neural-network architectures and modern generative modelling approaches.

The practical part will involve implementing the algorithms required for LISA data analysis.

— OBJECTIVES —

- The student will learn the basics of solving the equations of general relativity and gain an understanding of Bayesian parameter estimation.
- The student will acquire skills in implementing parameter estimation using MCMC methods and generative modelling (sometimes called simulation-based inference).

— PREREQUISITES —

- ☒ S1. Data Sciences
- ☒ S1. Numerical methods
- ☒ S2. Gravity & relativity
- ☒ S2. Statistics

— THEORY —

by NATALIA KORSAKOVA

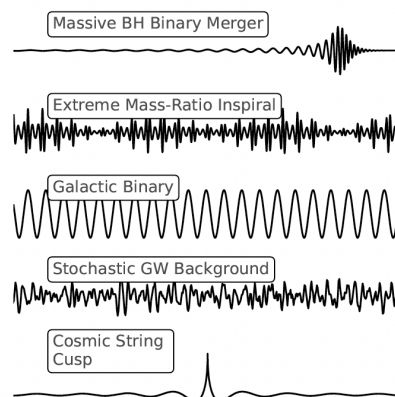
We will learn to derive gravitational waveforms as solutions to the Einstein field equations. We will study different approaches to solving Bayes' theorem and understand the similarities and differences between these methods.

— APPLICATIONS —

by NATALIA KORSAKOVA

We will implement some of the basic detection and parameter estimation algorithms and understand the challenges involved in LISA data analysis. In the project, we will attempt to

tackle some of the unsolved problems in LISA data analysis.



Typical gravitational wave signals that will be observed by LISA.

— MAIN PROGRESSION STEPS —

- **Week 1:** lectures on the introduction to gravitational waves and practical demonstrations
- **Week 2:** lectures on probability theory and exercises
- **Week 3:** lectures on machine learning and project starts

- **Week 4:** lectures on generative modelling and project
- **Weeks 5-7:** project

— EVALUATION —

- **Theory grade [30%]**
 - Oral exam (70%): theoretical question, base calculus from lectures
 - Presentation of an article (30%): critical spirit
- **Practice grade [30%]**
 - Project: initiative, progress, analysis, thought-process
- **Defense grade [40%]**
 - Oral and slides quality
 - Context
 - Project / Personal work
 - Answers to questions

— BIBLIOGRAPHY & RESOURCES —

- Schutz, A first course in general relativity
- Bishop, Deep learning
- LISA red book

— CONTACT —

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