



UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Current and future challenges in gravitational-wave astronomy

2223-113R-03

Title

Current and future challenges in gravitational-wave astronomy

Teacher(s)

Dott. Riccardo Buscicchio, dott. Michele Mancarella, dott. Costantino Pacilio

Language

English

Short description

GW State of the art (2 hours - Riccardo Buscicchio, Costantino Pacilio, Michele Mancarella)

LVC events

LVC populations

Current and future runs (O4, O5, post-O5)

Prospects: Earth and space based interferometers of third generation (ET, CE, LISA)

Toolkit (2 hours - Riccardo Buscicchio, Costantino Pacilio, Michele Mancarella)

Bayesian inference: event likelihoods, matched filtering, SNR, overlapping events

Population inference: hierarchical inference, hyperparameters, stacking, unresolved signals
Model selection: Evidence, Bayes factor, parameterized vs un-parameterized models, M-open vs M-closed scenario

LISA (4 hours - Riccardo Buscicchio)

Mission, Data model (1 hour):

Mission concept, challenges
time dependent response, low-frequency approximation, equal vs unequal arms
time-delay-interferometry
the (quasi) null-channel

Source models (1.5 hours)

chirping, drifting, monochromatic, polichromatic
overlapping signals, stochastic, glitch, gaps, the confusion noise

Towards the Global Fit (1.5 hours)

stochastic: metropolis hastings, mcmc, nested sampling, hamiltonian, particle swarm
likelihood-free, gaussian processes, normalizing flows, gibbs samplers
evidence for multiple sources, Savage-Dickey ratio, the Global fit

Tests of GR with GWs (4 hours)

Strong field tests part 1 (1 hr - Costantino Pacilio)

IMR-consistency test
Stacking populations of events to enhance tests of GR
Present status with the LVC-catalog

Strong field tests part 2 (1 hr - Costantino Pacilio)

Ringdown and quasinormal modes
Black hole spectroscopy; Area Theorem
Present status with the LVC-catalog

Cosmology with GWs part 1 (1 hr - Michele Mancarella)

Reminder of LCDM cosmology at late times. FRLW, evidence for acceleration, concordance model
Open problems and tensions. Hubble tension.
Basics of GW cosmology: GWs from binaries at cosmological distances. Distance and redshift measurements.

Cosmology with GWs part 2 (1 hr - Michele Mancarella)

Standard and dark sirens
Testing GR at cosmological distances. Modified propagation equations.
Results with current data

3G ground-based detectors: Einstein Telescope (4 hours)

Science with 3G ground-based detectors (1 hr - Costantino Pacilio)

Forecasts tools (1 hr - Michele Mancarella)

Fisher matrix approximation
Public tools

Cosmology with the Einstein telescope (1 hr - Michele Mancarella)

Strong-field tests of GR (1 hr - Costantino Pacilio)

CFU / Hours

2 CFU / 16 hours

Teaching period

February- May 2023

Sustainable Development Goals
