UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

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