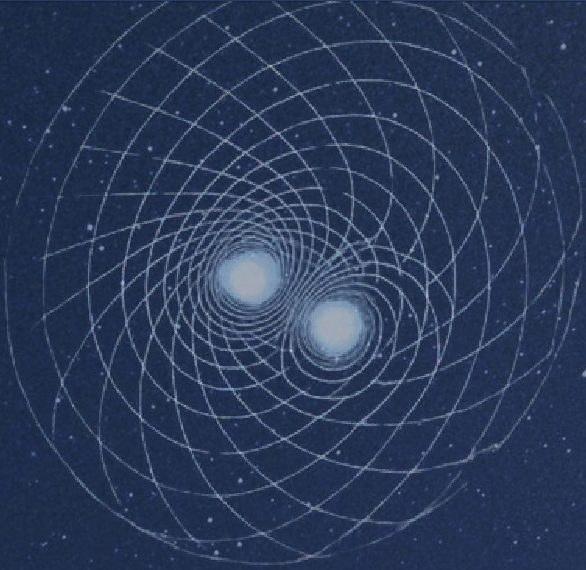

PAS Rome Meeting 2026

GRAVITATIONAL WAVES AND DETECTION TECHNOLOGIES

BOOK OF ABSTRACTS

16 - 17 III 2026
Rome, Italy

PAS Rome Meeting 2026

GRAVITATIONAL WAVES AND DETECTION TECHNOLOGIES

Rome 2025

Conference Venue:

Polish Academy of Sciences – Scientific Centre in Rome
Vicolo Doria 2, int. 6, 00187 Rome, Italy

Scientific Advisory Board

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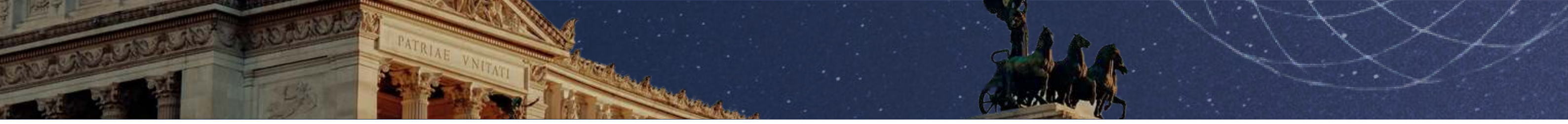
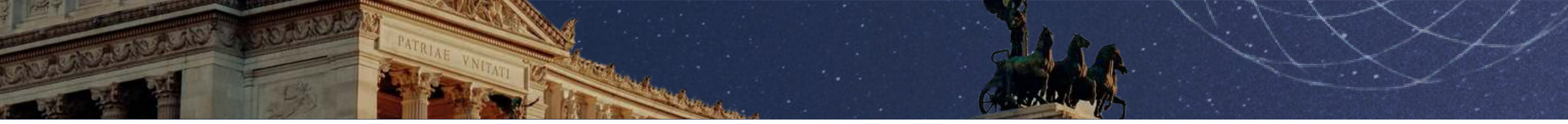


PROGRAMME
MONDAY, 16.03.2026

9:30 - 10:45	**Registration and Welcome Coffee**
10:45 - 11:00	**Official Opening**
11:00 - 13:00	**PLENARY SESSION I**
11:00 - 11:30	**Listening to the Universe: Recent Discoveries from LIGO–Virgo–KAGRA** Andrzej Kolak
11:30 - 12:00	**Einstein Telescope and the World of Binaries** Tomasz Bulik
12:00 - 12:30	**Einstein Telescope - the Future of Gravitational-Wave Observations** Jan Harms
12:30 - 13:00	**Overview of the Virgo Upgrade Project** Alessio Rocchi
13:00 - 14:00	**Lunch Break**
14:00 - 15:30	**PLENARY SESSION II**
14:00 - 14:30	**Squeezed Light for Gravitational-Wave Detection: Current Performance and Future Pathways** Mikhail Korobko
14:30 - 14:50	**Upgrades to the Detection Optical Benches of Virgo in Preparation for the Next Observing Run O5** Anne Daumas
14:50 - 15:10	**New Instrumented Baffles for the Main Optical Arms of the Virgo Experiment** Mario Martinez
15:10 - 15:30	**Status of Crystalline Monolithic Suspension for ET-LF** Michele Arcangelo Dicorato, Nicolo Baldicchi
15:30 - 16:00	**Coffee Break**
16:00 - 17:20	**PLENARY SESSION III**
16:00 - 16:20	**Birefringence Measurements on Crystalline Silicon** Luca Craighero
16:20 - 16:40	**Validation of the Interferometric Detection System of LISA on Ground** Maxime Vincent
16:40 - 17:00	**A Deep RL Framework for Locking Optimization in Simulated Optical Cavities** Andrea Svizzeretto
17:00 - 17:20	**Towards an Anomaly Detection Pipeline for Gravitational Waves at the ET** Huw Haigh
18:30 - 20:30	**Social Event**



PROGRAMME
TUESDAY, 17.03.2026

09:00 - 10:30 PLENARY SESSION IV

09:00 - 09:20 **Can We Form Gravitational Wave Sources from Binaries? The Role of Stellar Winds and Envelope Structure in the Formation of the Most Massive Black Holes**
Amedeo Romagnolo

09:20 - 09:40 **Estimating the General Evolution of the Core-collapse Supernova High Frequency Feature in Interferometric Noise**
Alejandro Casallas Lagos

09:40 - 10:00 **Detecting the Microlensing Pattern in the Microlensed Long-Duration Signals**
Sudhagar Suyamprakasam

10:00 - 10:20 **Uncertainty Quantification in Gravitational-Wave Burst Waveform Reconstruction with coherent WaveBurst 2G**
Alessandro Martini

10:20 - 11:00 Coffee Break

11:00 - 12:00 PLENARY SESSION V

11:00 - 11:20 **Performance of the 4-year Operation of the IMC Instrumented Baffle in Virgo**
Dounia Nanadoumgar Lacroze

11:20 - 11:40 **From Data Acquisition to Noise Mitigation, Environmental Sensor Arrays in Gravitational-Wave Observatories**
Mariusz Suchenek

11:40 - 12:00 **Modelling Newtonian Noise of Acoustic Origin in the Caverns of the ET Gravitational Wave Detector**
François Gautier

12:00 - 14:00 Lunch Break

14:00 - 16:00 Final Roundtable: Insights, Outcomes, and Next Steps

PAN Rome Scientific Center

A.D. 1308 unipg UNIVERSITÀ DEGLI STUDI DI PERUGIA

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VIRGO

EINSTEIN TELESCOPE

Listening to the Universe: Recent Discoveries from LIGO–Virgo–KAGRA

Corresponding Author: krolak@impan.pl

Gravitational waves, predicted over a century ago by Einstein's theory of General Relativity, have become a powerful observational tool for probing the Universe. I will briefly introduce the physical nature of gravitational waves and the interferometric methods used to detect them. I shall present the scientific results from the recently completed fourth observation run of the LIGO, Virgo, and KAGRA detectors, highlighting key astrophysical discoveries and their implications for gravitational-wave astronomy. I will conclude by outlining the contributions of the Polgraw group within the Virgo Collaboration, emphasizing our role in data analysis and detector development.

Einstein Telescope and the World of Binaries

Corresponding Author: tb@astrouw.edu.pl

Gravitational waves, predicted over a century ago by Einstein's theory of General Relativity, have become a powerful observational tool for probing the Universe. I will briefly introduce the physical nature of gravitational waves and the interferometric methods used to detect them. I shall present the scientific results from the recently completed fourth observation run of the LIGO, Virgo, and KAGRA detectors, highlighting key astrophysical discoveries and their implications for gravitational-wave astronomy. I will conclude by outlining the contributions of the Polgraw group within the Virgo Collaboration, emphasizing our role in data analysis and detector development.

Can We Form Gravitational Wave Sources from Binaries? The Role of Stellar Winds and Envelope Structure in the Formation of the Most Massive Black Holes

Author: Amadeo Romagnolo[1]

[1] *University of California, San Diego*

Corresponding Author: amadeoromagnolo@gmail.com

The formation of black holes, especially those seen in Gaia binaries and gravitational wave events, is still not fully understood due to gaps in our knowledge of how massive stars evolve. Stellar winds play a key role in mass loss and significantly affect these evolutionary paths. However, existing models are hampered by outdated methods and considerable differences in their underlying assumptions. In this talk, I will share a detailed mapping of stellar winds and envelope structure for massive stars, examining how different physical choices impact their evolution and therefore the formation of gravitational wave sources. From all the uncertainties, robust evolutionary patterns emerge, which are common to most models. These patterns provide important insights into the progenitors of the black holes we observe, including their isolated evolution and the chances of binary mass transfer, thus serving as an essential resource for interpreting both current and future observational data.

A Deep RL Framework for Locking Optimization in Simulated Optical Cavities

Author: Andrea Svizzeretto[None]
Co-Author: Mateusz Bawaj[1]
[1] *Università degli Studi di Perugia*

Corresponding Author: andrea.svizzeretto1996@gmail.com

This work explores the use of Deep Reinforcement Learning (DRL) to optimize the locking procedure of high-finesse Fabry–Perot cavities, key components of gravitational-wave detectors. Improving and speeding up the lock acquisition process helps increase the detector's duty cycle. This task is challenging due to nonlinear effects such as ring-down and resonance drifts, which distort the optical signals used for control.

To address these difficulties, we develop a simulator of the optical response of a Fabry–Perot cavity and a custom Gymnasium environment that allows a DRL agent (DDPG) to interact with the system and learn optimal locking strategies. Finally, we present some results of several training sessions on different simulated optical cavities, including partial observability and domain randomization, laying the groundwork for SimToReal transfer.

Estimating the General Evolution of the Core-collapse Supernova High Frequency Feature in Interferometric Noise

Authors: Alejandro Casallas Lagos[1] ; Marek Szczepanczyk[1] ; Michele Zanolin[2]
[1] *University of Warsaw*
[2] *ERAU*

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Galactic core-collapse supernovae (CCSNe) are highly anticipated multi-messenger events, providing a natural laboratory where neutrinos, photons, and gravitational waves (GWs) can be observed together. Numerical simulations indicate that CCSN GW signals are inherently nondeterministic; however, they consistently exhibit a promising observable: the High-Frequency Feature (HFF), seen in time–frequency spectrograms as a rising track between 200 Hz and 2 kHz. We introduce a framework to extract and model the HFF directly from coherent WaveBurst (cWB) reconstructed data in LIGO interferometers. Building on previous linear-growth studies, we fit analytic first- and secondorder approximations to the HFF, recovering both its slope and a newly characterized curvature that describes the feature's nonlinear evolution across different SNRs. Applied to state-of-the-art CCSN waveforms, our method identifies the functional form of the HFF growth and determines the frequency at which it saturates. This provides a more complete description of the HFF and enhances its utility for CCSN parameter inference in future GW detections.

Upgrades to the Detection Optical Benches of Virgo in Preparation for the Next Observing Run O5

Author: Anne Daumas[None]

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The Virgo experiment, alongside the American LIGO and Japanese KAGRA detectors, forms an international network of gravitational wave detectors currently in operation. The Virgo detector is a three-kilometer-long double-recycled Fabry Perot Michelson interferometer built near Pisa, Italy. Challenges related to this current optical configuration of Virgo has lead to a redesign of the interferometer's recycling cavities for the next upgrade cycle, in order to improve instrument sensitivity and control. The new, non-degenerate recycling cavities design lead among other changes to a complete redesign of the auxiliary benches hosting the injection and detection optics. In this work we will present adaptions choices to the opto- -mechanical design of the detection benches for the stable recycling cavities to be implemented in Virgo, for which low beam jitter, low optical losses, high mode-match-

ing quality between the signal recycling cavity and output mode cleaner cavity, reduction of scattered light and protection of delicate components against power peaks to due interferometer misalignment, are all critical in order to collect the output beam which contains the gravitational wave signal.

Validation of the Interferometric Detection System of LISA on Ground

Author: Maxime Vincent[1]
[1] *APC CNRS*

Corresponding Author: mvincent@apc.in2p3.fr

The French contribution to the LISA Consortium, specifically on the instrumental aspect, centers on developing optical ground support equipment (OGSE) for the validation of LISA's performance before it takes flight. More specifically, one of the tasks of the French community is to test and validate the performance of the Interferometric Detection System (IDS). The IDS Test Set-Up is currently under development in order to verify that picometric stability is reached within the IDS (EM and QM) and characterize the TTL Rx tilt-to-length coupling coefficient of the interferometers of the OB (coupling between the relative angle between beams and the length readout of the interferometer). The IDS Test Set-Up is composed of several sub-assemblies including the IDS, the Beams Simulator and the Test Mass Simulator (+ all the support equipment). The APC laboratory is in charge of the development of the Beams Simulator optical bench that is intended to simulate and stimulate the interface with the MOSA on the distant spacecraft and the adjacent MOSA on the local spacecraft. For this contribution, I will briefly present the functioning principle of the Beams Simulator and the overall IDS Test Set Up, I will then present the optical simulation tool set developed in order to verify that specification are well set and verify that the bench as designed will reach it's planned performance and be able to measure the performance of the LISA instrument.

Performance of the 4-year Operation of the IMC Instrumented Baffle in Virgo

Author: Dounia Nanadoumgar Lacroze[None]

Corresponding Author: dnala@ifae.es

The suspended end mirror in the Input Mode Cleaner (IMC) cavity of the Advanced Virgo Plus interferometer was equipped with an enhanced baffle model in May 2021.

This baffle is instrumented with active sensors next to the test mass to enable the monitoring of the scattered light in the cavity. We assess the performance and stability of the instrument after 4 years of operation. We study the distribution of scattered light, its evolution and show that the instrumented baffle can be used as a monitor of the laser stability and alignment in the cavity.

Detecting the Microlensing Pattern in the Microlensed Long-Duration Signals

Author: Sudhagar Suyamprakasam[None] ; Michal Bejger[None]

Corresponding Author: sudhagar@camk.edu.pl

An asymmetric rotating neutron star may emit quasi-monochromatic gravitational waves. Detecting such signals with second-generation detectors requires long observation times due to their low GW amplitudes. If the signal is also microlensed, the lens's mass temporarily magnifies the signal amplitude, aiding detection and providing a distinct microlensing pattern. We explore the prospects for detecting microlensed continuous gravitational wave signals using the point-mass lens approximation. We examine the feasible parameter space and strategies for directed microlensing searches. To identify the microlensing pattern, we employ both traditional data analysis techniques and machine learning methods using simulated data from ground-based detectors, specifically applying the semi-coherent Time Domain F-statistic method.

New Instrumented Baffles for the Main Optical Arms of the Virgo Experiment

Author: Mario Martinez[1]
[1] *ICREA-IFAE Barcelona*

Corresponding Author: mmp@ifae.es

Building on the successful four-year operation of the first instrumented baffle installed on the Input Mode Cleaner (IMC) mirror of Virgo in 2021, IFAE has developed two new large instrumented baffles for deployment in the main arms of the detector. Each baffle, approximately 80 cm in diameter and equipped with 120 photosensors, will be installed at the entrance of the input mirror towers. The system features a 1 kHz DAQ readout and supports both wired and wireless operation.

We will present the design and construction of these baffles, together with performance studies validated through detailed simulations. The new instrumentation is expected to provide continuous monitoring of stray light within the arm cavities, assist in cavity pre-alignment during commissioning and operation, support the validation of optical stray-light models, and aid in the identification of potential noise sources by correlating baffle data with glitches observed in the interferometer output and control channels.

From Data Acquisition to Noise Mitigation, Environmental Sensor Arrays in Gravitational-Wave Observatories

Author: Mariusz Suchenek[None]

Corresponding Author: msuchenek@camk.edu.pl

Gravitational-wave observatories increasingly rely on sophisticated environmental sensor arrays to characterize and mitigate noise sources that couple into interferometric detector measurements. As detectors such as Advanced LIGO and Virgo continue to reach higher sensitivities, a comprehensive set of noise-reduction strategies ranging from passive isolation to active suppression is required to control environmental disturbances and enhance detector performance. There two low-frequency noise sources which are significant, seismic and infrasound, which together generate Newtonian noise. Starting around 2020, the Virgo observatory deployed an extensive network of seismic sensors specifically designed to support Newtonian-noise studies and mitigation efforts. Complementary environmental sensor arrays provide the spatially resolved data necessary to reconstruct local pressure gradients and ground motion. When combined with precise timing distribution systems, these measurements enable detailed modeling of density perturbations and their impact on the detector test masses.

Status of Crystalline Monolithic Suspension for ET-LF

Authors: Flavio Travasso[None]; Michele Arcangelo Dicorato[None]; Nicolo Baldicchi[1]

[1] *Università degli studi di Perugia*

Corresponding Author: michele.dicorato@pg.infn.it ; nicolo.baldicchi@pg.infn,it

The next generation of interferometric gravitational wave detectors faces limitations due to excessive thermal noise in key optical and suspension systems, particularly below 10 Hz. To address this issue, cryogenic solutions are being adopted. Dedicated studies are focusing on the creation of cryogenic payloads with quasi-monolithic suspensions, identifying suitable materials for substrates, suspensions, and suspension steering stages, ensuring optimal thermal, mechanical, and optical properties. This talk aims to describe the main lines of research currently underway, the materials being studied (primarily silicon and sapphire, but also including new materials such as composites and germanium), the main challenges in creating a quasi-monolithic suspension, and what is currently being done to overcome these challenges. It is worth noting that this work is currently being addressed by a huge collaborative effort between universities, research institutions, and private companies, an effort that is leading to multiple solutions and promising results.

Birefringence Measurements on Crystalline Silicon

Authors: Amelie Heying[1] ; Disha Kapasi[2] ; Joshua Smith[2] ; Luca Craighero[3] ; Maya Bakijan[2] ; Nico Salazar[4] ; Pietro Laudenzi[5]

[1] *Hamilton College*

[2] *California State University Fullerton*

[3] *Università degli Studi di Torino*

[4] *Citrus College*

[5] *Università degli Studi di Roma "La Sapienza"*

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Crystalline Silicon cooled to cryogenic temperatures is a promising material for next--generation gravitational-wave detector optics. Crystalline Silicon has low mechanical loss, so it enables low thermal noise at low temperatures, and it also has two points of zero thermal expansion at 123 K and 10 K and high thermal conductivity, so it does not get easily deformed by thermal loads. One of the sources of noise in GW interferometers is the birefringence present in both the substrate and the coatings of the optics. The goal of this experiment is to map the birefringence in a crystalline silicon sample at 2 μm laser wavelength using an optical cavity. The measurement will first be done at room temperature to verify its operation. Then it will be set up in a cryogenic testbed to make the measurement at low temperatures. This talk will present the design concept and early testing of the experiment.

Towards an Anomaly Detection Pipeline for Gravitational Waves at the ET

Authors: Gianluca Inguglia[1] ; Huw Haigh[None]

[1] *MBI - Austrian Academy of Sciences*

Corresponding Author: huw.haigh@oeaw.ac.at

We present a study of deep convolutional autoencoders applied to anomaly detection of GW signals. This initial work focuses on short-duration signals (< 2s), corresponding to mergers that involve, or form, intermediate mass black holes. Such burst signals are notably difficult to disentangle from both background noise and glitches that may occur during data taking. We utilise the simulated noise and merger catalogue provided as part of the ET Mock Data Challenge. Weak supervision is employed during training, whereby the model is directly optimised to separate 2D spectrograms containing signal (injected into ET noise) from those containing only noise. With the addition of the weak supervision, the model is able to recover all targeted IMBH merger signals from the MDC dataset. Furthermore, it was found that the model could generalize to mass ranges below this, which were unseen during training. Work is currently ongoing to expand the method towards 3-way classification of signals, glitches and noise, with the goal of developing an model--independent autoencoder based detection/classification pipeline, that is capable of handling the high event rates expected in the ET-era.

Uncertainty Quantification in Gravitational-Wave Burst Waveform Reconstruction with Coherent WaveBurst 2G

Authors: Alessandro Martini[1] ; Giovanni Prodi[2]

[1] *Virgo*

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Minimally modelled searches play a critical role in the detection of short-duration gravitationalwave transients whose morphologies are poorly constrained by existing waveform models. Among these approaches, the Coherent WaveBurst (cWB) algorithm has proven to be a robust and versatile tool for burst searches, enabling the coherent detection and reconstruction of gravitational-wave signals directly from the detector data. However, the limited use of prior information inherent to minimally modelled analyses poses significant challenges for the quality and reliability of waveform reconstruction.

In this contribution, we discuss recent and prospective improvements to the waveform reconstruction process within the cWB framework and address a longstanding open problem in burst analyses: the quantitative assessment of uncertainties associated with reconstructed waveforms. At present, robust confidence intervals or confidence belts for reconstructed burst signals are not routinely available, limiting the interpretability of reconstruction results for astrophysical inference and follow-up studies. We explore the use of bootstrap-based techniques as a viable and flexible approach to uncertainty quantification in minimally modelled waveform reconstruction. Both parametric and non-parametric bootstrap methods are investigated, with the goal of constructing confidence belts around reconstructed waveforms that capture statistical variability induced by detector noise. We discuss practical implementation strategies, and present results demonstrating their potential to provide meaningful uncertainty estimates. This work represents a step toward more statistically robust waveform reconstruction in gravitational-wave burst searches.

Modelling Newtonian Noise of Acoustic Origin in the Caverns of the ET Gravitational Wave Detector

Author: François Gautier[1]
Co-Authors: Lionel Maurin ; Matteo Barsuglia ; Soizic Terrien[2]
[1] *Laboratoire d'Acoustique de l'Université du Mans, UMR CNRS 6613*
[2] *LAUM*

Corresponding Author: fancois@gautier@univ-lemans.fr

Among the noises affecting GW detectors, Newtonian noise of seismic or acoustic origin could limit sensitivity at low frequencies, below a few tens of Hz. This presentation focuses on modeling Newtonian noise of acoustic origin, resulting from technical noises in caverns and experimental halls. A significant contribution to this technical noise is specifically linked to the operation of the air conditioning system (HVAC), which is essential to ensure the thermal stability and cleanliness of these rooms. The acoustic pressure present in the environment is responsible for small fluctuations in density. The fluctuating gravitational field that is induced directly causes random forces on sensitive optical elements, such as the interferometer's test masses. Acoustic Newtonian Noise is quantified using a numerical model of the acoustic field in an arm-end cavern. This model describes the modal response of the room under the effect of acoustic sources equivalent to the vents of the ventilation system, which allows the calculation of Newtonian noise based on equipment parameters (rotation speed, vent position). The criticality of this noise source for the detector is demonstated, given the sensitivity targeted by ET in the low frequency range. Possible solutions for reducing Newtonian acoustic noise (room geometry, tower position, position of HVAC system inlets and outlets) are discussed based on the proposed physical model.

Squeezed Light for Gravitational-Wave Detection: Current Performance and Future Pathways

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Squeezed light has become a baseline quantum technology in gravitational-wave detectors, delivering routine quantum-noise reduction and driving the success of recent astrophysical observations. Next-generation observatories, including the Einstein Telescope, are being designed with squeezedlight operation as a core part of the sensitivity concept: key subsystems are optimized for compatibility with quantum-noise suppression. This drives requirements such as ultra-low-loss optics and readout chains, multi-kilometre-scale filter cavities for frequency-dependent squeezing, and optical layouts and control strategies that minimize loss, phase noise, scattered light, and other imperfections. In this talk, I will give an overview of squeezed-light technology, recap the story of its success in current detectors, and outline the opportunities and the practical challenges for implementing squeezing in the next-generation gravitational-wave observatories.

Final Roundtable: Insights, Outcomes, and Next Steps

This closing discussion will synthesize key insights from the meeting, identify strategic opportunities for international contributions to current and next-generation gravitational-wave detectors and encourage new collaborations across participating communities.