Young scientist presentations

Sergio Javier Arbiol Val (IFJ, Krakow), *Overview of ATLAS forward proton detectors: performance and new physics results*

A key focus of the physics program at the LHC is the study of head-on proton-proton collisions. However, an important class of physics can be studied for cases where the protons narrowly miss one another and remain intact. In such cases, the electromagnetic fields surrounding the protons can interact producing high-energy photon-photon collisions. Alternatively, interactions mediated by the strong force can also result in intact forward scattered protons, providing probes of quantum chromodynamics (QCD). In order to aid identification and provide unique information about these rare interactions, instrumentation to detect and measure protons scattered through very small angles is installed in the beam pipe far downstream of the interaction point. We describe the ATLAS Forward Proton AFP Detectors, focusing on the performance of their Silicon Tracker system. At the end, a glimpse on the latest physics results will be given.

Cristian Cogollos (MPP, Munich), *The current RADES experiments*

Benjamin Csizi (Innsbruck), *Calibration of complex morphology and colour gradient biases in cosmic shear measurements for precision cosmology with Euclid*

The ongoing Euclid survey will produce unprecedented constraints on cosmological parameters and probe the properties of the dark sector Universe, thanks to its combination of unforeseen statistical power and high resolution imaging. Being a cosmic shear survey, it requires accurate image simulations which reproduce the properties of the observed data and of the underlying galaxy population, to enable weak lensing science with precisely calibrated galaxy shape and photometric redshift measurements. Therefore, previously neglected sources of potential bias, such as complexity in the galaxy morphology or colour gradients across the light profile have to be accounted for and implemented in the simulation pipeline. To account for these effects, we developed a deep generative model based on dual-channel HST training data, that facilitates the creation of noise-free, PSF-independent, realistic image simulations which include complex substructure and colour gradients. We tested the impact of the model on shear calibration, and validated its performance comparing various morphological parameters on both the training set and the reconstructed network outputs. We show that this bias has to be accounted for for next-generation weak lensing surveys to unlock the full power of the cosmological inference and enable tight constraints on the properties of dark energy and the validity of the Lambda-CDM model.

Andrii Dashko (DESY Hamburg), *Perturbative aspects of the electroweak phase transitions in the cxSM*

We present a detailed study of the precision calculations of higher-order contributions to effective potential with the application of three-dimensional effective field theories (3D EFTs). Our work focuses on the *thermodynamic quantification and description of electroweak phase transitions in the early Universe for the complex singlet extended Standard Model (cxSM). In particular, we address the issue of gauge and scale dependencies associated with the effective potential, which can lead to ambiguities when calculating thermodynamical quantities from the effective potential. In addition, we study the ambiguities in commonly used renormalization schemes of the effective potential. The phenomenological implications of our results are discussed.*

Paola Delgado (Prague, CAS), *Searching for Spin-2 Dark Matter with Gravitational Wave Detectors*

I will explore how Earth-based gravitational wave detectors, such as LIGO and Virgo, can be leveraged to search for spin-2 dark matter. These particles are expected to produce a continuous wave signal, making them well-suited for search techniques originally developed for continuous gravitational waves. In this context, we employ a semi-coherent method to analyze the signal, obtaining equalized spectra for a range of masses and coupling constants. I will present the corresponding sensitivity estimates and discuss the potential of these searches in constraining spin-2 dark matter models.

Jost von der Driesch (KIT Karlsruhe), *Measurements of the inclusive W and Z boson production cross sections and their ratios with the CMS experiment at sqrt(s) = 13.6 TeV*

The massive W and Z bosons play a fundamental role in the standard model (SM) of particle physics. The precise measurement of their production cross sections is important not only for probing theoretical predictions at high orders of perturbative QCD, but also for physics beyond the SM, where their productions are background processes. For these reasons, the production cross sections have been measured in proton-proton collisions many times in the past, at varying center-of-mass (COM) energies.

In 2022 the LHC began colliding protons at the unprecedented COM energy of 13.6 TeV, following a long shutdown phase since 2018. This contribution presents the results of the inclusive cross section measurement of W and Z boson production with the CMS experiment at this new COM energy.

Charles Frontonteil (Innsbruck), *Probing gravity with quantum sensing networks*

Recent advances in quantum computing and quantum communication with quantum optical systems make it possible to realize large-scale quantum networks. While mainly explored in the contexts of scalable quantum computers and long-distance quantum communication, these systems also hold great promise for distributed quantum sensing. We propose the use of qubit-based, universally programmable quantum sensing networks as a novel perspective to address fundamental questions at the interface of general relativity and quantum physics. We analyze such a "gravity-quantum lab" by developing a quantum optical framework to account for weak gravity effects on entanglement distribution protocols and resulting non-local Ramsey spectroscopy experiments. This allows us to design and study experiments using long-distance entanglement to probe gravity effects on quantum mechanical systems.

Silvia Gasparotto (Barcelona), ***Gravitational wave memory from primordial black hole mergers***

The gravitational wave signal from binary compact objects below the merger frequency consists of two main components: the inspiral signal and the nonlinear memory. We assess the sensitivity of upcoming detectors to these contributions, particularly for events with merger frequencies beyond the detector bandwidth. For light primordial black holes, we find that current and future detectors are more sensitive to the inspiral phase, while the memory signal becomes significant only for extremely light masses and unrealistically high primordial black hole abundances. Our analysis accounts for the evolution of primordial black hole binaries, enabling a direct comparison between high-frequency detectors, which probe the merger phase, and low-frequency interferometers, which are sensitive to the inspiral and memory components.

Serena Giardino (AEI Potsdam), ***Testing modified gravity with lensing of gravitational waves beyond geometric optics***

Gravitational waves propagating through the universe encounter massive objects acting as lenses, which break the symmetries of FLRW. This allows for distinctive effects on the waves' polarizations and for new interactions bearing signatures of modified gravity. I will describe the potential of gravitational wave lensing as a testing ground for gravity beyond GR with future GW detectors, focusing on scalar-tensor theories with symmetron screening. These are particularly interesting since screened environments naturally modify GW propagation while evading local gravity tests. I will focus on effects beyond the geometric optics approximation, allowing for lens-induced diffraction, which can constrain any modified theory without the need for EM counterparts.

Emilie Hertig (Cambridge), ***Towards new constraints on inflation with the Simons Observatory***

Polarization anisotropies of the cosmic microwave background (CMB) encode a wealth of information on particle physics at the highest energies. In the coming decade, a new generation of instruments starting with the Simons Observatory (SO) will either detect or tightly constrain the amplitude of B-mode patterns produced by inflationary gravitational waves. My presentation will focus on techniques developed to mitigate secondary B-modes induced by Galactic foregrounds and weak gravitational lensing, aiming to extract the primordial signal with optimal precision. I will highlight recent performance forecasts for SO and initial efforts to apply these methods to the new data currently being collected. Finally, I will outline future avenues for combining CMB data with other cosmological probes to unveil the fundamental physics of the very early Universe.

Alex Jenkins (Cambridge), ***Cold atom analogues for vacuum decay***

False vacuum decay plays a pivotal role in many models of particle physics and the early Universe. However, we lack a satisfying theoretical understanding of this process, with existing approaches working only in imaginary (Euclidean) time, and relying on assumptions that have yet to be empirically tested. I will describe ongoing efforts to simulate vacuum decay in tabletop experiments, using ultra-cold atomic condensates which mimic the behaviour of relativistic quantum fields. I will present recent theoretical work *to understand this analogy using semiclassical lattice simulations, and will discuss opportunities and challenges for realising these analogues in the laboratory.*

Monika Juzek (IFJ, Krakow), *Fake tau lepton background estimation in the search for H^{+-} --> tau nu with ATLAS Run-II data (2015-2018)*

Searching for Beyond Standard Model (BSM) physics is a key objective of the ATLAS experiment at the LHC. Many BSM scenarios, such as two-Higgs-doublet models (2HDM) and the Minimal Supersymmetric Standard Model (MSSM), predict additional Higgs bosons, including a charged Higgs boson (H±). In these models, the decay H±→τν is expected to have a significant branching fraction over a wide H± mass range.A major challenge in analyses involving reconstructed tau leptons is the estimation of backgrounds from jets misidentified as hadronically decaying taus. To address this, a dedicated data-driven fake factor method is employed. This poster presents the fake tau background estimation procedure in the context of the H±→τν search, along with the latest results from the full Run-II (2015–2018) dataset of s=13 TeV proton–proton collisions recorded by the ATLAS detector.

Sudip Kumar Kar (Jagiellonian Univ., Krakow), *Exact Wigner function for Chiral Spirals*

At present, our understanding of the non-equilibrium aspects of a relativistic spin fluid is derived from the study of Wigner function coupled with the semiclassical expansion. In our work, we present an exact computation (up to quantum loop corrections) of the Wigner functions for quarks in a field of oscillating pion condensate. The oscillating pion condensate enters the equation of motion as a mean field, allowing for an exact solution. The spinors thus obtained are used to compute all components of the Wigner functions. Axial current obtained using these exact Wigner functions reproduce expressions in existing literature. In addition, our analysis also reveals a scenario that indicate incompatibility with the conventional semi-classical expansion.

Theophanes Karydas (Amsterdam), *A relativistic framework for black hole inspirals in dark matter spikes*

Dark matter overdensities around black holes can perturb the dynamical evolution of a companion object orbiting inside of them, and thus significantly alter the emitted gravitational waveform (GW). For extreme mass ratio inspirals (EMRIs), the accurate modelling of waveforms is key to successfully extracting information about their environments. In this work, we developed a general relativistic framework to quantify the environmental effect of a dark matter spike to an extreme or intermediate mass ratio inspiral accounting for the background spacetime of the central black hole and the spin degrees of freedom of the companion. In doing so, we uncover the GW mismatch of including said framework and a distinct mass-spin correlation during the inspiral.

Yves Kini (Amsterdam), *Constraining neutron star masses and radii through pulse profile modelling*

Pulse profile modeling (PPM) is a relativistic ray-tracing technique used to infer the mass, radius, and surface map of neutron stars. This technique has been applied to study the properties of rotation-powered millisecond pulsars observed by the Neutron Star Interior Composition Explorer (NICER). PPM can also be *used to analyze thermonuclear burst oscillation (TBO) sources, which are accreting neutron stars that develop surface hotspots during Type I X-ray bursts (thermonuclear explosions). In the poster session, I will provide an overview of the mass and radius constraints derived from NICER data. I will also outline the analysis methods we have developed to accurately determine the properties of TBO sources, presenting current results for the TBO source XTE J1814−338.*

Lucy Komisel (MPP Munich), ***Cosmic strings and domain walls of the QCD quark condensate with and without a hidden axion***

The chiral quark condensate of QCD, which spontaneously breaks the anomalous axial symmetry, gives rise to axionic type global string-wall systems. If a Peccei-Quinn type axion exists in the theory, the axionic strings are in general accompanied by winding of the QCD quark condensate. Depending on the axion model the winding can proceed either in the η' or in the pion direction. This determines the structure of fermionic zero modes and the anomaly inflow which has important astrophysical consequences. We point out that η' and pion string-wall systems exist in pure QCD, independently of the hidden axion. Strikingly, even if a hidden axion exists, the early cosmology can be entirely dominated by string-wall systems formed by the QCD quark condensate. We also discuss their role in the QCD phase transition and in heavy-ion physics.

Prisco Lo Chiatto (MPP Munich), ***Following Quantum Imprints in the Realm of Large Multiplicity***

We uncover a correspondence between large multiplicity amplitude and the tunneling action in the quantum mechanical anharmonic double well. The tunneling action corresponds, in the exact Wentzel-Kramers-Brillouin interpretation to quantum mechanics, to a nonperturbative contribution to the quantization condition. The correspondence is exact in a 't Hooft-like double scaling limit, where classical behaviour is expected to dominate. In the semiclassical limit, thus, the anharmonic oscillator betrays its quantum origin, in what we call the "quantum imprint". We comment on possible implications for the correspondence principle, classicalization, and the resurgent connection between perturbative and nonperturbative physics.

Antonino Midiri (Geneve), ***Refined initial conditions for gravitational waves production from irrotational fluid perturbations in cosmological first order phase transitions***

First-Order Phase Transitions in the early universe are a possible source of a Stochastic Gravitational Wave Background. The expanding scalar broken-phase bubbles can produce irrotational perturbations in the primordial plasma and lead, after bubble collisions, to the development of sound waves, which are one of the main sources of Gravitational Waves. The analytical derivation of the Gravitational Wave spectrum from sound waves relies on a detailed knowledge of the fluid kinetic spectrum before collisions. We show how the discontinuities in the velocity and enthalpy fluid profiles, together with causality, completely determine the spectral shape in the expansion phase at small and large scales, and how the statistical time distribution of bubble nucleation and collision determine its evolution, and hence the initial conditions for Gravitational Wave production after collisions.

Tomasz Mroz (IFJ, Krakow), *Alignment of the ATLAS Forward Proton Detector with Run 3 Data*

The ATLAS Forward Proton (AFP) detector plays a crucial role in the study of central exclusive processes, such as $\gamma\gamma \rightarrow \ell^+\ell^-$, by detecting forward-scattered protons. Accurate alignment of the AFP tracking system is essential for precise proton kinematics and event reconstruction. In this study, we present an AFP alignment procedure based on e^+e^- events from LHC Run 3 data. The method compares the proton position predicted from the central ATLAS detector to the actual hit position in AFP, allowing for fine-tuning of the detector alignment. The results are used to independently validate a previous alignment analysis performed with $\mu^+\mu^-$ events, demonstrating consistency across leptonic final states. This cross-check strengthens the reliability of AFP-based measurements and supports future studies of exclusive photon-induced processes with improved confidence in detector performance.

Mainak Mukhopadhay (Penn State), *Neutrino signatures from magnetar remnants of binary neutron star mergers: coincident detection prospects with GWs*

Binary neutron-star (BNS) mergers are accompanied by multi-messenger emissions, including gravitational wave (GW), neutrino, and electromagnetic signals. Some fraction of BNS mergers may result in a rapidly spinning magnetar as a remnant, which can enhance both the EM and neutrino emissions. I will elaborate on the possible neutrino signatures from such systems. I will also focus on the possibility and prospects of performing stacked triggered searches for high-energy and ultra-high energy neutrinos from BNS mergers in general, at IceCube-Gen2, GRAND, and RNO-G, using the next generation of GW detectors.

Stefan Nellen-Mondragon (HEPHY, ÖAW and Univ. Vienna), *Time-resolution in the Migdal effect*

The Migdal effect consists of an excitation or ionization of the electronic state of an atom due to the sudden change in momentum of the nucleus. This effect would also be present in dark matter-WIMP scatterings and has been used to extend the sensitivity of direct detection experiments at lower (~GeV) masses. On the other hand, the Migdal effect depends on the scattering time. In particular, for sufficiently slow scattering events the electronic transitions would be effectively adiabatic and no electron emission would take place. In this work we work out the impact of time-dependence on the Migdal effect and its implications for noble gas based direct detection experiments.

Nadine Nussbaumer (Heidelberg), *To bounce or not to bounce in generalized Proca theory and beyond*

It is notoriously difficult to construct a stable non-singular bouncing cosmology that avoids all possible instabilities throughout the entire evolution of the universe. In this work, we explore whether a non-singular bounce driven by a specific class of modifications of General Relativity, the vector-tensor generalized Proca theories, can be constructed without encountering any pathologies in linear perturbation theory. We find that such models unavoidably lead either to strong coupling in the tensor or the scalar sector, or instabilities in the matter sector during the bouncing phase. As our analysis is performed in a gauge-independent way, this result can be cast in the form of a no-go theorem for non-singular bounces with generalized Proca. In contrast to the no-go theorem found for Horndeski theories, however, it cannot be *evaded by considering beyond generalized Proca theory. At the core of our result lies the non-dynamical nature of the temporal component of the vector field, which renders it an ill-suited mediator for a bouncing solution.*

Julia Oseka (Jagiellonian Univ., Krakow), *Causality in non-linear quantum wave equations*

Non-linear quantum wave equations often arise as an effective description of collective dynamics of many-particle systems, as exemplified by the Gross-Pitaevskii equation in Bose-Einstein Condensate. They also appear in wave function collapse models (e.g. the Diosi-Penrose model) aimed at explaining the quantum-to-classical transition. In the context of the standard free Schrödinger evolution it is well-known that initially localised wave packets can escape beyond the light cone, which leads to potential troubles with Einstein's causality. We have investigated the superluminal propagation of wave packets for three distinct non-linear wave equations. Our findings indicate that self-interaction actually improves the causality properties as compared to the free Schrödinger evolution, despite its inherent non-local character.

Kateryna Radchenko (DESY Hamburg), *New probes of a first order electroweak phase transition*

In this poster, I will analyze the potential signatures of a first-order electroweak phase transition in the early Universe. Since the Standard Model does not allow for such a transition, I will explore a simple extension of the scalar sector — the Two Higgs Doublet Model (2HDM) — which introduces a second Higgs doublet.

If the phase transition is strong enough, it proceeds via the spontaneous nucleation of bubbles of the electroweak vacuum. The collisions of these bubbles can generate a stochastic gravitational wave background, potentially detectable by LISA.

I will focus on two key probes of this scenario: collider searches and cosmological signals. On the collider side, I will discuss recent ATLAS searches for $A \to ZH$ decays in $\ell^+ \ell^- t \bar{t}$ and $\nu \nu b \bar{b}$ final states. Additionally, I will explore the complementarity of these searches with other LHC analyses and examine the interplay between collider experiments and space-based gravitational wave detectors.

Brendan Regnery (Karlsruhe), *4D tracking for future colliders*

The past two decades in silicon sensor R&D has resulted in silicon sensors capable of O(10) um spatial resolution and O(10) ps temporal resolution. This has enabled the possibility of a once seemingly unattainable objective: ‘4D’ tracking—the concept of having multiple tracking layers capable of both high spatial and temporal resolution. At KIT, we are collaborating with INFN Torino to study the Resistive AC-coupled Silicon Detector (RSD), a promising candidate ‘4D’ sensor that uses a continuous gain layer and charge sharing to maintain high spatial and temporal resolution while using a low number of readout channels and providing an intrinsic 100% fill factor.

Henrik Rose (Potsdam), ***Linking microphysics and cosmology through next-generation detections of neutron star mergers***

Neutron-star mergers offer an unparalleled opportunity for joint analysis of theories valid at or physical data obtained on both extremely large and small scales. The stars' interior structure is governed by matter at the highest densities found anywhere in the universe and impacts tidal effects gravitationally observed in mergers, complementing information from present and future ion collision experiments. Similarly, interpreting electromagnetic observations of transients due to radioactive decay of their ejecta hinges on improved experimental data on neutron-rich ions found in the currently built ion-beam facilities. I will discuss how we can employ machine-learning methods to efficiently analyse these links between physical specialties and what cosmological constraints they will imply.

Giona Sala (Aachen), ***Inferring cosmological parameters from galaxy and dark sirens cross-correlation***

The observation of galaxies and gravitational waves (GW) emitted by dark sirens provides two different and complementary measures of distance, respectively redshift and luminosity distance. Under the assumption that both dark sirens and galaxies trace the distribution of matter up to some bias parameters, it is possible to infer cosmological parameters by cross correlating their density maps. As the number of resolved GW sources is growing with rapidly advancing technologies, we estimate the population of dark sirens that will be detected by future observations such as Ligo-Virgo-Kagra, the Einstein Telescope and the Cosmic Explorer. We compute the cross-correlation between mock data from dark sirens and galaxy redshift surveys. We fit the cross-correlation angular power spectrum by running Markov Chain Monte Carlo (MCMC) with an innovative likelihood. Our results highlight the potential of this method to provide new and independent constraints on cosmological parameters like H_0.

Kristof Schmieden (Mainz), ***Towards the detection of high frequency gravitational waves***

Several sources of high frequency gravitational waves are discussed in new physics models, most prominently primordial black hole merges and axion super-radiance. Both production mechanisms lead to signals with distinct features. Challenges of detecting gravitational waves from both exemplary sources are discussed as well as prospects for the detection of GW using a network of RF cavity based detectors.

Jonathan Schubert (MPP Munich), ***How to find a heavy neutral lepton***

Heavy neutral leptons are arguably one of the best motived classes of hypothetical new particles as they may solve several puzzles of fundamental physics. An interesting avenue to search for these feebly interacting particles are fixed target experiments. Due to the large number of interactions in the target, heavy neutral leptons may be produced abundantly. Several such experiments are planned in the near future, prompting an effort to scrutinise the relevant phenomenology which we will outline. We further report on first steps of the ongoing search at the NA62 experiment at the SPS. When operating this experiment in beam dump mode, the downstream decays of heavy neutral leptons could be observed, using *the existing detector apparatus, with excellent sensitivity to a cosmologically interesting region of possible parameter space.*

Gloria Senatore (Zürich), ***The neutrinoless double beta-decay experiment LEGEND - R&D on wavelength-shifting reflector materials for the liquid argon instrumentation***

The LEGEND (Large Enriched Germanium Experiment for Neutrinoless double beta Decay) experiment aims at the detection of the neutrinoless double beta decay, which, if observed, would lead to groundbreaking implications in neutrino physics and in cosmology. Located at Laboratori Nazionali del Gran Sasso, Italy, the experiment will discover if the neutrino is a Majorana particle (i.e. it coincides with its own antiparticle), reaching a sensitivity to the half-life of the decay of 10^{27} *years in the first phase, LEGEND-200, and of* 10^{28} *years in the second phase, LEGEND-1000. The first phase aims to employ 200 kg of high-purity germanium (HPGe) detectors enriched in 76Ge, the double beta emitter, and started datataking in March 2023, with a run-time of five years. The second phase will operate 1000 kg of HPGe detectors and plans to be operative in 2030, with a designed run-time of ten years.*

The germanium detectors are contained in a cryostat filled with liquid argon (LAr). The LAr instrumentation is an important apparatus of the experiment, responsible for collecting the scintillation light generated by the background particles interacting with the LAr. Wavelength-shifting reflector (WLSR) materials are important to shift the wavelength of the light, so to enhance the match with the optical sensors, and to reflect light back to the optical sensors themselves.

My project is to study and characterize WLSR materials for LEGEND-1000 and will be important for the final selection of the material. The new materials I will investigate include polyethylene naphtalate (PEN), thin films based on polytetrafluoroethylene (PTFE) and polyethylene terephthalate (PET), and white reflective paints which could also be considered for the cryostat covering. I am evaluating the optical and mechanical properties, the radiopurity and the possibility to scale to large dimensions of the candidate samples I have collected, considering the larger size of LEGEND-1000.

Devanshu Sharma (Aachen), ***Non perturbative dynamics of stochastic inflation beyond slow-roll***

The statistics of large-scale perturbations from inflation can be accurately captured by the stochastic delta-N formalism. This non-perturbative approach does not require solving the perturbation equations of quantum field theory and at the same time, accounts for the quantum diffusion effects of the small-scale perturbations, which are still not classicalized. This talk and poster will shed light on a first-of-its-kind numerical algorithm to compute the two-point statistics of inflationary perturbations via the non-perturbative approach, applied to slow-roll and ultra-slow-roll models of single-field inflation.

Paper : https://arxiv.org/abs/2411.08854 (Accepted for publication in JCAP)

Mukul Sholapurkar (HEPHY, ÖAW), ***Sensitivity to new physics with quantum acoustics***

Phonons are an important sensing channel to look for new physics. Recent advances in the field of quantum acoustics allow the control of individual GHz phonons. The detector we consider in this *presentation is composed of superconducting transmon qubits coupled to high-overtone bulk acoustic resonators (hBARs), and operates in the GHz - 10 GHz frequency range. Sensitivity to new physics that excites phonons in this frequency range within the hBAR can then be achieved by reading out qubit excitations. I will briefly discuss the details of this technology before showing the expected sensitivity to new physics signals. In particular, I will talk about signals from dark photon dark matter and high frequency gravitational waves, where we find that a future detector can complement current haloscope experiments*.

Isak Stomberg (Valencia), *Higgsless insights to gravitational waves from cosmological phase transitions*

A cosmological stochastic gravitational wave background is a compelling target for existing and upcoming detectors like pulsar timing arrays and LISA. In this poster/presentation, I explore cosmological phase transitions as a potential source of these gravitational waves and introduce a novel "Higgsless" simulation approach to predict the resulting spectrum. I will also share recent findings on strong phase transitions and discuss key insights emerging from this work.

Roxane Theriault (Jagiellonian Univ., Krakow), *Relic graviton background from gravitational Cherenkov radiation*

Scalar particles traveling faster than a subluminal gravitational wave generate gravitons via gravitational Cherenkov radiation. We investigated graviton production by the primordial plasma within the framework of modified gravity in the early Universe, generating a relic graviton background. By requiring the relic graviton background to remain consistent with the Big Bang Nucleosynthesis constraint, we derived limits on the gravitational wave speed at early times in certain modified gravity theories.

Katarina Trailovic (Ljubljana), *Functional determinants and lifetime of the Standard Model*

We revisit the computation of the electroweak vacuum decay rate in the Standard Model, incorporating the full one-loop prefactor and focusing on the gauge degrees of freedom. Using group theoretical arguments, we derive the correct degeneracy factors in the functional determinant and identify an overcounting of transverse modes in previous calculations. The new result modifies the gauge fields' contribution by 6% and leads to a slight decrease of the previously predicted lifetime of the electroweak vacuum.

Rodrigo Vicente (Amsterdam), *Probing ultralight scalars around black holes with LIGO-Virgo-KAGRA observations*

If dark matter is made of some new ultralight bosonic particle, dense structures are expected to form around stellar-mass black holes (e.g., via superradiance, accretion or dynamical capture). These non-trivial environments are expected to affect the inspiraling (and associated gravitational-wave signal) of compact binaries, opening the possibility for using gravitational-wave observations to probe the presence of such dark matter structures. Here, I will discuss how to model such effects on black hole coalescences: from numerical relativity simulations to analytical methods. I will also present the first constraints on the presence of ultralight scalar structures derived from present LIGO-Virgo-KAGRA observations.

Kristyna Vitulova (Univ. Vienna), ***Enhancing gravitational wave detection with deep convolutional autoencoders***

Gravitational wave detection relies on matched filtering, a method that struggles with high noise levels and can miss unconventional signals. This research explores the application of deep convolutional autoencoders to improve signal extraction by learning the noise characteristics of next-generation detectors, such as the Einstein Telescope. By developing and optimizing advanced architectures, we aim to enhance anomaly detection in gravitational wave data, increasing robustness and sensitivity. The results could provide a foundation for integrating machine learning into future gravitational wave observatories, improving detection rates and scientific discovery potential.