Gravitational Wave Probes of Physics Beyond Standard Model 4

Report of Contributions

Contribution ID: **1** Type: **not specified**

Bubble wall velocity from hydrodynamics

Terminal velocity reached by bubble walls in cosmological first-order phase transitions is an important parameter determining both primordial gravitational wave spectrum and the production of baryon asymmetry in models of electroweak baryogenesis. In this talk I discuss the recent results for local thermal equilibrium approximation for which, using hydrodynamic simulations, we have confirmed that pure hydrodynamic backreaction can lead to steady-state expansion. However, this is not the generic outcome. Instead, it is much more common to observe runaways, as the early-stage dynamics right after the nucleation allow the bubble walls to achieve supersonic velocities before the heated fluid shell in front of the bubble is formed. In order to capture this effect, we generalized the analytical methods beyond the local thermal equilibrium and find a qualitative way to predict whether the runaway is physical, which has a crucial impact on cosmological observables.

Primary authors: LEWICKI, Marek (University of Warsaw); ZYCH, Mateusz (University of Warsaw)

Contribution ID: **2** Type: **not specified**

Black holes and gravitational waves from phase transitions in realistic models

Among all the possible candidates for Dark Matter, one appealing example is a population of Primordial Black Holes, which could have been borne by various processes in the early stages of the Universe. In this talk, I will investigate the formation of such objects as the result of the collapse of energy density fluctuations originating from supercooled first-order phase transitions. I will stress the importance of including the second-order corrections in the expansion of the bubble nucleation rate and show its implications for the production of Primordial Black Holes as well as the emission of Gravitational Wave signals. Finally, I will illustrate the application of this formalism to a realistic particle model, showing that in certain regions of parameter space both abundant production of Primordial Black Holes and emission of strong Gravitational Wave signals is realized.

Primary author: TOCZEK, Piotr (University of Warsaw)

Contribution ID: **3** Type: **not specified**

Primordial Graviton Production and Detection Prospects in the String Pre-Big Bang Scenario

We investigate the mechanism of primordial graviton production within the framework of string cosmology's pre-Big Bang scenario, focusing on the interpretation of the NANOGrav signal as a relic stochastic background of primordial gravitons.

Our analysis shows that the minimal version of the pre-Big Bang scenario encounters limitations in explaining the observed signal. However, generalized non-minimal extensions, whether preserving or breaking the S-duality symmetry during the high curvature regime (string phase), make this interpretation feasible.

In both frameworks, significant gravitational wave signals can be produced, spanning a wide range of frequencies. These signals have the potential to be detected by upcoming interferometric experiments such as Advanced LIGO, the Einstein Telescope, LISA, and DECIGO, offering the exciting prospect of multi-band detection.

This presentation will be based on:

1. I. Ben-Dayan, G. Calcagni, M. Gasperini, A. Mazumdar, E. Pavone, U. Thattarampilly and A. Verma, Gravitational-wave background in bouncing models from semi-classical, quantum and string gravity, JCAP 09, 026 (2024).
2. P. Conzinu, G. Fanizza, M. Gasperini, E. Pavone, L. Tedesco, and G. Veneziano, Constraints on the parameters of the Pre-Big Bang scenario from NANOGrav data, JCAP 02, 039 (2025).

Primary authors: PAVONE, Eliseo (INFN Sezione di Bari and Università degli Studi di Bari); Prof. VENEZIANO, Gabriele (CERN, College de France); Prof. FANIZZA, Giuseppe (LUM, Bari); Prof. TEDESCO, Luigi (INFN, Bari and Università degli studi di Bari); Prof. GASPERINI, Maurizio (INFN, Bari); Dr CONZINU, Pietro (Università di Parma)

Contribution ID: **4** Type: **not specified**

Primordial Gravitational Waves from Phase Transitions during Reheating

We study primordial gravitational waves (GWs) generated from first-order phase transitions (PTs) during cosmic reheating. Using a minimal particle physics model, with a general parametrization of the inflation energy density and the evolution of the Standard Model temperature, we explore the conditions under which PTs occur and determine the corresponding PT parameters. We find that, in certain cosmological scenarios, PTs can be delayed and prolonged compared to the standard post-inflationary evolution. Finally, incorporating these PT parameters, we compute the resulting GW spectrum while accounting for the uncertainties related to cosmic reheating.

Primary authors: BANIK, Amitayus (Chungbuk National University); BERNAL, Nicolás (New York University, Abu Dhabi); HAJKARIM, Fazlollah (University of Oklahoma)

Contribution ID: **5** Type: **not specified**

Probing leptogenesis with scalar induced gravitational waves

We demonstrate in this work that scalar-induced gravitational waves (SIGWs) can serve as a natural and powerful probe of thermal leptogenesis occurring at extremely high scales-beyond the reach of conventional particle physics experiments. As a proof of concept, we present a simple leptogenesis model in which an early matter-dominated phase, tracking the leptogenesis scale, is responsible for the production of GWs sourced by the early structure (halos of the scalar field giving mass to the right-handed neutrinos seeding leptogenesis) formation taking place before the Big Bang Nucleosynthesis (BBN). Leveraging recent N-body and lattice simulation results for GW computations in the nonlinear regime, we show that it is possible to establish a direct link between the frequency and the amplitude of these SIGWs and the thermal leptogenesis scale.

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Contribution ID: **6** Type: **not specified**

Probing SUSY at Gravitational Wave Observatories

Under the assumption that the recent pulsar timing array evidence for a stochastic gravitational wave (GW) background at nanohertz frequencies is generated by metastable cosmic strings, we analyze the potential of present and future GW observatories for probing the change of particle degrees of freedom caused, e.g., by a supersymmetric (SUSY) extension of the Standard Model (SM). We find that signs of the characteristic doubling of degrees of freedom predicted by SUSY could be detected at Einstein Telescope and Cosmic Explorer even if the masses of the SUSY partner particles are as high as about 10^4 TeV, far above the reach of any currently envisioned particle collider. We also discuss the detection prospects for the case that some entropy production, e.g. from a late decaying modulus field inducing a temporary matter domination phase in the evolution of the universe, somewhat dilutes the GW spectrum, delaying discovery of the stochastic GW background at LIGO-Virgo-KAGRA. In our analysis we focus on SUSY, but any theory beyond the SM predicting a significant increase of particle degrees of freedom could be probed this way.

Primary author: HINZE, Kevin

Contribution ID: **7** Type: **not specified**

Bubble Nucleation and Gravitational Waves from Strongly Coupled QFT's.

Gravitational waves (GWs) produced during first-order phase transitions (FOPTs) in strongly coupled quantum field theories (QFTs) pose a significant challenge for precise prediction due to the complexities of strong coupling. In this talk, we present a method for predicting the GW spectra of such theories by integrating holographic techniques with lattice data from pure SU(N) Yang-Mills theory. We show how holography can be used to construct an effective action, which then serves as the basis for studying bubble nucleation and predicting the resulting GW spectra. Finally, we discuss the broader phenomenological implications of our results.

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Co-authors: Mr MORGANTE, Enrico (University of Trieste); Mr SCHWALLER, Pedro (JGU Mainz)

Contribution ID: **8** Type: **not specified**

Gravitational waves from preheating in α-attractors

In multi-field inflationary models, couplings between fields are not limited to the potential of the model, but can also be present in kinetic terms. In such a case, they can be interpreted as a non-trivial structure of the space of fields. Non-vanishing curvature of this space can lead, if negative, to a new phenomenon called geometrical destabilization.

α-attractors are a very promising class of inflationary models. Their
predictions for small values of α parameter are in remarkably good agreement with the CMB data obtained by the Planck satellite. Since α-attractor models are by construction multi-field models, dynamics of the additional spectator field can play a role in the (p)reheating.

When investigating the two-field α-attractor T-model, we have found that geometrical destabilization during preheating leads to efficient fragmentation of the spectator field. As a result, the transition from the inflationary era to the radiation domination era is practically instantaneous and much faster than previously found in the effective theory including only the inflaton field. Recently, due to development of numerical software, we were able to overcome deficiencies of our primary analysis and got deeper insight into parametric dependence of the problem. Moreover, we estimated the spectrum of gravitational waves emitted during preheating in this model.

Primary author: KRAJEWSKI, Tomasz (Institute of Fundamental Technological Research PAS)

Contribution ID: **9** Type: **not specified**

Gravitational Waves from a First-Order Phase Transition of the Inflaton

We explore the production of gravitational waves resulting from a first-order phase transition (FOPT) in a non-minimally coupled "Dark Higgs Inflation" model. Utilizing a single scalar field both as the inflaton and as the Dark Higgs breaking the gauge symmetry in the dark sector, we demonstrate the feasibility of a unified framework for inflation and observable gravitational waves from a FOPT.

Primary author: KERSTEN, Jörn (Yonsei University)

Contribution ID: **10** Type: **not specified**

”Theoretical and Observational Bound on Scalar fields In Modified Symmetric Teleparallel Gravity”

In this presentation, I will provide an overview of our recent research contributions in the context of scalar field cosmology within the framework of symmetric teleparallel gravity. Specifically, I will discuss the findings from our three published papers, along with two additional manuscripts that are currently under review.

A significant portion of our work focuses on the Dirac-Born-Infeld (DBI) scalar field, which is motivated by string theory and serves as a compelling candidate for modeling dark energy and cosmic inflation due to its non-canonical kinetic structure. We explore the dynamics of this field in symmetric teleparallel gravity and examine how its potential can be constrained using the most up-to-date cosmological observations, particularly the latest data from the Dark Energy Spectroscopic Instrument (DESI).

Additionally, we evaluate the compatibility of our models with the Swampland conjectures, which aim to distinguish effective field theories that can be consistently embedded in a quantum theory of gravity from those that cannot. For this purpose, we employ a statistical Gaussian approach to assess the likelihood of various scalar potentials satisfying the Swampland criteria.

Furthermore, we extend our analysis by incorporating curvature perturbations into the dynamical system. We demonstrate how the full system of cosmological equations—including both background dynamics and first-order scalar perturbations—can be solved exactly within our theoretical framework. This allows us to probe the evolution of structure in the universe and refine our understanding of viable scalar field models in modified gravity theories.
References:
1.https://onlinelibrary.wiley.com/doi/10.1002/prop.202300006
2.https://iopscience.iop.org/article/10.1088/1402-4896/ad39b5
3.https://iopscience.iop.org/article/10.1088/1674-1137/ad50aa

Primary author: GHOSH, Sayantan ((Senior) Research Scholar (PhD student))

Contribution ID: **11** Type: **not specified**

Supercooled Audible Axions

We present the audible axion mechanism extended by a period of supercooling that delays the onset of axion oscillations. While the original setup relies on a large axion decay constant and coupling to a dark Abelian gauge field to produce sizable gravitational wave signals, in this talk we discuss how supercooling opens up the testable parameter space and reduces the required coupling to α $gtrsim1$.
Added to that, we showcase that the emission of gravitational waves via the axion coupling to the Standard Model photon in the presence of Schwinger pair production becomes possible, generating a strong signal in the μHz or ultra-high frequency range.

Primary authors: GERLACH, Christopher (Johannes Gutenberg-Universität Mainz); SCHMITT, Daniel (Goethe University Frankfurt am Main); Prof. SCHWALLER, Pedro (Johannes Gutenberg-Universität Mainz)

Contribution ID: **12** Type: **not specified**

Gravitational Waves from a Higgs-like spectator field

We study stochastic gravitational waves (GW) sourced by a Higgs-like spectator field via the modulated reheating mechanism. The curvature perturbations generated by the spectator in de Sitter vacuum are blue-tilted and strongly non-Gaussian. They must be suppressed on scales probed by the CMB anisotropies but can grow large on sub-Mpc scales, generating observationally testable stochastic GWs. We study the GW signals from a Higgs-like spectator scalar with a non-minimal coupling to spacetime curvature in a modulated reheating setup with shift-symmetric dimension-five couplings for the inflaton field. We find that for Standard Model values of the gauge and Yukawa couplings, the GWs are unobservably small but for larger couplings the setup can produce GWs detectable with the BBO survey.

Primary authors: BENACO, Michele (University of Jyväskylä); NURMI, Sami (University of Jyväskylä); KARAMITROS, Dimitrios (University of Jyväskylä); TUOMINEN, Kimmo (University of Helsinki)

Contribution ID: **13** Type: **not specified**

Supercooled Dark Scalar Phase Transitions explanation of NANOGrav data

The evidence of a Stochastic Gravitational Wave Background (SGWB) in the nHz frequency range is posed to open a new window on the Universe. A preferred explanation relies on a supercooled first order phase transition at the 100 MeV–GeV scale. We address address its feasibility going from the particle physics model to the production of the gravitational waves. We take a minimal approach for the dark sector model introducing the fewest ingredient required, namely a new U(1) gauge group and a dark scalar that dynamically breaks the symmetry. Supercooling poses challenges in the analysis that put under question the feasibility of this explanation: we address them, going beyond previous studies by carefully considering the effects of a vacuum domination phase and explicitly tracking the phase transition from its onset to its completion. We find that the proposed model can successfully give origin to the observed PTA SGWB signal. The strong supercooling imposes a correlation between the new gauge coupling and the scalar quartic one, leading to a significant hierarchy between the (heavier) gauge boson and the dark scalar. ultimately, information on phase transitions from SGWB observations could provide a direct probe of the microphysics of the Early Universe and be used to guide future searches of dark sectors in laboratories.

Primary authors: Dr COSTA, Francesco (Charles University in Prague); HOEFKEN ZINK, Jaime (Narodowe Centrum Badań Jądrowych (NCBJ)); Dr LUCENTE, Michele (University of Bologna); Dr ROSAURO-ALCARAZ, Salvador (University of Bologna); Prof. PASCOLI, Silvia (University of Bologna)

Contribution ID: **14** Type: **not specified**

Pre-thermalized Gravitational Waves

We investigate a novel gravitational wave (GW) production mechanism from gravitons generated during the pre-thermal phase of cosmic reheating, where the energy density is dominated by non-thermalized inflaton decay products, dubbed reheatons. We consider multiple production channels, including: i) pure inflaton-inflaton annihilation, ii) graviton Bremsstrahlung from inflaton decay, iii) scatterings between an inflaton and a reheaton, and iv) scatterings among reheatons. To determine the resulting GW spectrum, we solve the Boltzmann equation to obtain the graviton phase-space distribution for each channel. We find that the third channel, iii), dominates due to the large occupation number of reheatons at highly-energetic states during the pre-thermalization phase. Notably, in scenarios with a low inflaton mass, the GW spectrum could fall within the sensitivity range of future experiments such as the Einstein Telescope, the Cosmic Explorer, the Big Bang Observer, and ultimate DECIGO.

Primary author: BERNAL, Nicolás (New York University Abu Dhabi)

Contribution ID: **15** Type: **not specified**

Microlensing effect in the long-duration gravitational wave signals originating from Galactic sources

Detection of quasi-monochromatic, long-duration (continuous) gravitational wave radiation emitted by, e.g., asymmetric rotating neutron stars, planetary or asteroid mass - primordial BH (PBH) binaries during their in-spiral phase in our Galaxy requires a long observation time to distinguish it from the detector's noise. If this signal is additionally microlensed by a lensing object located in the Galaxy, its magnitude would be temporarily magnified, which may lead to its discovery and allow probing of the physical nature of the lensing object and the source. We study the observational feasibility of Galactic microlensing of continuous gravitational wave signals in the point mass lens approximation by discussing the parameter space of the problem as well as by applying a gravitational wave detection method, the Time Domain F-statistic search, to ground-based detectors in the simulated data.

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Co-authors: Prof. BIESIADA, Marek; Dr BEJGER, Michał; Dr CIECIELĄG, Paweł; Dr FIGURA, Przemysław; Mr HARIKUMAR, Sreekanth

Contribution ID: **16** Type: **not specified**

Paths Through the Dark: Comparing Approaches to Cosmological FOPTs

We explore the dynamics of cosmological phase transitions in a dark sector model featuring a dark photon associated with a U(1)D gauge symmetry. Our analysis focuses on two complementary approaches to construct the effective potential: an scale invariant model with the Coleman-Weinberg potential, both using the high-temperature approximation and a full numerical evaluation of the thermal integrals, and a dimensionally reduced 3D effective theory built with DRalgo, at both leading and next-to-leading order.

We investigate how these methods impact the characterization of the phase transition, particularly in the supercooled regime.

Our results show the importance of method choice when predicting observable signatures, and establish a benchmark for future studies of first-order phase transitions in models with weakly coupled dark sectors.

Primary authors: PUCHADES IBÁÑEZ, Cristina (JGU Mainz); Dr MADGE, Eric (IFT); Dr RAMIREZ-QUEZADA, Maura E. (JGU); SCHWALLER, Pedro (Johannes Gutenberg-Universität Mainz)

Contribution ID: **17** Type: **not specified**

Using graviational waves to look for dark matter (in)directly

Gravitational wave detectors offer promising probes to search for dark matter, both directly and indirectly. If dark matter originates from a background of ultralight gauge bosons, these bosons could exert forces on the test masses of gravitational wave detectors, inducing displacements with characteristic frequencies determined by the boson mass. On the indirect side, the Fermi satellite has observed an excess of GeV gamma rays from the Galactic Center. The origin of this excess remains under debate, with leading hypotheses including dark matter annihilation or emission from a population of millisecond pulsars. The continuous gravitational wave searches conducted by the LVK collaboration have strong potential to help resolve this long-standing question.

Primary author: ZHAO, Yue (University of Utah)

Contribution ID: **18** Type: **not specified**

Searches for Inflationary Gravitational Waves in the NANOGrav 15 yr data-set

In this talk, I will summarize some of our efforts to interpret the GWB-like signal observed by the NANOGrav collaboration as inflationary gravitational waves, by sampling reheating temperature, tensor spectral index, and the running of the tensor spectral index. I will show that there is available parameter space to describe the signal, even if we impose constraints from CMB, LVK, and do not overabound the effective number of neutrino species. Two scenarios are possible: i) one in which a very late reheating period takes place, falling into the NANOGrav band, or ii) one with a more conventional large reheating temperature with a non-vanishing running of the tensor spectral index.

Primary author: LINO DOS SANTOS, Rafael Robson (NCBJ, Warsaw)

Contribution ID: **19** Type: **not specified**

Gravitational waves from supermassive black holes at pulsar timing arrays

Inspiralling SMBH binaries constitute a natural explanation of the gravitational wave (GW) background discovered in pulsar timing array (PTA) data. In this talk, I will present a fast semianalytical computation of the expected GW background from SMBH binaries and discuss the SMBH fit to the PTA data that shows evidence of environmental effects or binary eccentricities. I will identify signatures that can be used to distinguish between these effects and to confirm whether the signal comes from SMBH binaries, and show how the PTA GW observations can be linked to the JWST observations of dual AGNs and little red dots. Finally, I will discuss potential ways to test dark matter properties through SMBH observations.

Primary author: VASKONEN, Ville (University of Padova and KBFI)

Contribution ID: **20** Type: **not specified**

C-parity, magnetic monopoles and higher frequency gravitational waves

We will discuss the complementary signatures of gravitational waves and observable flux of the GUT monopoles when $SO(10)$ grand unified symmetry is spontaneously broken via the left-right symmetric model with C-parity also unbroken [C converts $Q \to -Q$, where Q is the electric charge operator in $SO(10)$.] This breaking produces the topologically stable GUT monopole as well as a GUT scale C-string. The subsequent breaking at an intermediate scale of C-parity produces domain walls bounded by C-strings, found by Kibble, Lazarides and Shafi. A limited number of inflationary e-foldings experienced during these breakings can yield an observable number density of primordial GUT monopoles. The C-strings also experience this inflationary phase, and the subsequent string-wall network decays through the emission of gravitational waves. We estimate the gravitational wave spectrum from these composite structures over a range of values of the domain wall tension σ. Depending on σ the spectrum displays a peak in the higher frequency range between 10^2 to 10^5 Hz.

Primary authors: SHAFI, Qaisar; MAJI, Rinku (Institute for Basic Science, CTPU - CGA)

Contribution ID: **21** Type: **not specified**

Bubble wall dynamics from non equilibrium quantum field theory

Gravitational waves (GWs) produced during a first-order phase transition are a favourite candidate as a probe of beyond the standard model physics at future space-based experiments. The spectrum of produced GWs depends strongly on the terminal velocity at which bubbles of the broken phase expand in the plasma, and in particular on whether this velocity can become ultrarelativistic.
In this talk, I show how the language of non-equilibrium quantum field theory, together with the 2PI effective action, is the natural framework to study the dynamics of the bubble wall. I derive the full equation of motion for the bubble wall and the two-point functions, and show that it can be brought into a convenient form by expanding in gradients. This yields an equation that generalises the one usually employed.
In the ultrarelativistic regime, I compute the pressure induced by pair production of heavy particles, mixing with a heavy species and transition radiation of gauge bosons, thus providing a first-principle derivation of the known sources of friction.
This talk is based on 2504.13725

Primary authors: GARBRECHT, Björn (Technical University of Munich); TAMARIT, Carlos (Mainz Institute of Theoretical Physics); CAROSI, Matthias (Technical University of Munich); VANVLASSELAER, Miguel (Vrije University of Bruxelles); AI, Wenyuan (Austrian Academy of Sciences)

Contribution ID: **22** Type: **not specified**

Dynamical nonlinear tails in black hole ringdown

Nonlinear tails in black hole perturbations, arising from second-order effects, present a distinct departure from the well-known Price tail of linear theory. We present an analytical derivation of the power law indices and amplitudes for nonlinear tails stemming from outgoing sources, and validate these predictions to percent-level accuracy with numerical simulations. We then perform a perturbative analysis on the dynamical formation of nonlinear tails in a self-interacting scalar field model, wherein the nonlinear tails are sourced by a $\lambda\Phi^3$ cubic coupling. Due to cascading mode excitations and back-reactions, nonlinear tails with t^{-l-1} power law are sourced in each harmonic mode, dominating the late time behavior of the scalar perturbations. In verification, we conducted numerical simulations of the self-interacting scalar model, including all real spherical harmonic (RSH) with $l \leq 4$ and their respective nonlinear couplings. We find general agreement between the predicted and numerical power law indices and amplitudes for the nonlinear tails, with the exception of $l = 4$ modes, which display t^{-4} power law instead of the predicted t^{-5}. This discrepancy is due to distortion in the source of the tails, which is caused by another nonlinear effect. These results establish nonlinear tails as universal features of black hole dynamics, with implications for gravitational wave astronomy: they may imprint observable signatures in merger remnants, offering novel probes of strong-field gravity and nonlinear mode couplings.

Primary authors: LING, Siyang (City University of Hong Kong); Ms SHAH, Sabeela (City University of Hong Kong); Prof. WONG, Sam (City University of Hong Kong)

Contribution ID: **23** Type: **not specified**

Prospecting a scalar Singlet-Triplet two component Dark Matter model with Gravitational Waves

We investigate gravitational wave (GW) production from a first-order electroweak phase transition (FOEWPT) in a two-component dark matter (DM) scenario. The Higgs sector of the Standard Model (SM) is extended by a complex scalar singlet and a hyperchargeless ($Y = 0$) scalar triplet. In this setup, the neutral component of the triplet serves as a DM candidate under a $\mathbb{Z}_2$ symmetry. Meanwhile, the pseudo-scalar part of the complex scalar, charged under a global $U(1)$ symmetry, which is explicitly broken by a $\mathbb{Z}_3$-symmetric term in the scalar potential, acts as the second DM candidate. The triplet scalar DM typically contributes only 10–20% to the relic density in the sub-TeV region and remains underabundant up to ~ 1.9 TeV due to strong $SU(2)_L$ gauge interactions. However, in our two-component setup, DM-DM conversion enhances the triplet contribution up to 50–60% in the sub-TeV range. The pseudo-scalar DM, on the other hand, benefits from a suppressed spin-independent direct detection cross-section, allowing a larger viable parameter space consistent with current bounds. We highlight the interplay between cosmological and collider constraints, the correlations among model parameters, and identify regions that evade current limits but are within the sensitivity range of future and current detectors, such as XENON1T, LZ-2024, and DARWIN. Next, we study the FOPT dynamics and emphasize its connection with DM phenomenology. The resulting GW spectrum is estimated and analyzed for detectability using both the conventional power-law integrated (PLI) sensitivity and the recently proposed peak-integrated sensitivity curves (PISC). Our analysis reveals that a novel region of the model's parameter space, compatible with DM observables, can produce a detectable GW signal. These signals are within reach of future space-based GW detectors such as LISA, BBO, DECIGO, and DECIGOcorr. Our investigation complements the collider searches for BSM new physics at the DM and GW detector frontiers.

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Co-author: Prof. GHOSH, Pradipta (IIT Delhi)

Contribution ID: **24** Type: **not specified**

Memory Burden effects mimic the reheating signatures on SGWB from ultra low mass PBHs

Ultra-low mass primordial black holes (PBH), briefly dominating the expansion of the universe, would leave detectable imprints in the secondary stochastic gravitational wave background (SGWB). Such a scenario leads to a characteristic doubly peaked spectrum of SGWB and strongly depends on the Hawking evaporation of such light PBHs. However, these observable signatures are significantly altered if the memory burden effect during the evaporation of PBHs is taken into account. We show that for the SGWB induced by PBH density fluctuations, the memory burden effects on the Hawking evaporation of ultra-low mass PBHs can mimic the signal arising due to the non-standard reheating epoch before PBH domination. This degeneracy can be broken by the simultaneous detection of the first peak in the SGWB, which is typically induced by the inflationary adiabatic perturbations.

Primary authors: LEWICKI, Marek (University of Warsaw); HAQUE, Md Riajul; BHAUMIK, Nilanjandev; JAIN, Rajeev Kumar

Contribution ID: **25** Type: **not specified**

Pulsar Timing Array Evidence for Self–Interacting Dark Matter in Super-Massive Black-Hole Mergers

Pulsar timing arrays (PTAs) have now revealed a nano-hertz stochastic gravitational-wave background whose amplitude and spectral shape are consistent with a cosmic population of merging super-massive black-hole (SMBH) binaries. Explaining how such binaries bridge the "final parsec" separation before gravitational radiation dominates remains a key challenge. Following the mechanism proposed by Alonso-Álvarez *et al.* (2024), we investigate whether dynamical friction from a dense spike of *self-interacting dark matter* (SIDM) surrounding each SMBH can simultaneously solve the final-parsec problem *and* imprint the mild low-frequency turnover hinted at in current PTA data.

We perform the first full-likelihood Bayesian analysis of this scenario using the NANOGrav 15-year data set. Employing a custom-corrected version of the holodeck pipeline, we sample
the joint posterior of SMBH-population, host-galaxy and SIDM parameters with an MCMC and marginalise over astrophysical uncertainties. The velocity-weighted cross section per unit mass is constrained to

$\langle \sigma v/m \rangle \;=\; 10^{\,2.9\pm0.5}\,\mathrm{cm}^2/(\mathrm{g\,km\,s^{-1}}), This range is fully compatible with independent inferences from dwarf-$
$galaxy cores and galaxy-cluster offsets, favouring a Yukawa-like velocity dependence mediated by an$ O(10–100)MeV
binaries within a Hubble time, whereas collisionless cold-DM spikes are disrupted too early.

Primary authors: Mr TIRUVASKAR, Shreyas (University of Canterbury (NZ)); GORDON, Chris (University of Canterbury (NZ))