5th EuCAPT Annual Symposium (online)

Report of Contributions

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

Neutron stars as laboratories

Tuesday, 6 May 2025 14:00 (30 minutes)

Presenter: RAJ, Nirmal (Indian Institute of Science)

Session Classification: Stars as Labs for Fundamental Physics

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

Probing light QCD axions with neutron stars

Tuesday, 6 May 2025 14:30 (15 minutes)

Presenter: SPRINGMANN, Konstantin (Weizmann)

Session Classification: Stars as Labs for Fundamental Physics

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

Looking for hybrid stars with neutrinos

Tuesday, 6 May 2025 14:45 (15 minutes)

Presenter: MARTINEZ-MIRAVE, Pablo (IFIC (CSIC-Univ. Valencia))

Session Classification: Stars as Labs for Fundamental Physics

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

Questions & discussion

Tuesday, 6 May 2025 15:06 (23 minutes)

Session Classification: Stars as Labs for Fundamental Physics

Contribution ID: **7**

Type: **not specified**

Panel Discussion. Panelists: Joe Bramante, David Curtin, Sam Witte

Tuesday, 6 May 2025 15:29 (30 minutes)

Session Classification: Stars as Labs for Fundamental Physics

Contribution ID: **8**

Type: **not specified**

Pulsar Timing Arrays

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

NANOGrav: Results and prospects

Monday, 5 May 2025 14:00 (30 minutes)

Presenter: MINGARELLI, Chiara (Flatiron Inst.)

Session Classification: Pulsar Timing Arrays

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

Dark matter searches with PTAs

Monday, 5 May 2025 14:30 (15 minutes)

Presenter: KIM, Hyungjin

Session Classification: Pulsar Timing Arrays

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

SMBHBs in light of PTA results

Monday, 5 May 2025 14:45 (15 minutes)

Presenter: SATO-POLITO, Gabriela (Princeton)

Session Classification: Pulsar Timing Arrays

Contribution ID: **12**

Type: **not specified**

Lightning talks + discussion

Session Classification: Pulsar Timing Arrays

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

Panel Discussion. Panelists: Bruce Allen, Stas Babak

Monday, 5 May 2025 15:30 (30 minutes)

Session Classification: Pulsar Timing Arrays

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

DESI results

Wednesday, 7 May 2025 14:00 (30 minutes)

Presenter: FONT RIBERA, Andreu (IFAE, Barcelona)

Session Classification: LambdaCDM and beyond

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

Fundamental Physics with Galaxy Surveys

Wednesday, 7 May 2025 14:30 (15 minutes)

Presenter: MORADINEZHAD, Azadeh (University of Geneva)

Session Classification: LambdaCDM and beyond

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

Updates on the Hubble tension

Wednesday, 7 May 2025 14:45 (15 minutes)

Presenter: SCHÖNEBERG, Nils (ICC University Barcelona)

Session Classification: LambdaCDM and beyond

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

Lightning talks + discussion

Session Classification: LambdaCDM and beyond

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

Panel Discussion. Panelists: Kazuya Koyama, Vivian Poulin, Zvonimir Vlah

Wednesday, 7 May 2025 15:30 (30 minutes)

Session Classification: LambdaCDM and beyond

Contribution ID: **26**   Type: **Stars as Labs**

Probing Axion-Nucleon Couplings with Supergiant Stars

Tuesday, 6 May 2025 15:00 (1 minute)

A finite axion-nucleon coupling enables the production of axions in stellar environments via the thermal excitation and subsequent de-excitation of ^{57}Fe isotopes.
Given its low-lying excited state at 14.4 keV, ^{57}Fe can be efficiently excited in the hot cores of supergiant stars, leading to axion emission. If these axions convert into photons in the Galactic magnetic field, they would produce a characteristic 14.4 keV line detectable by hard X-ray telescopes such as NuSTAR.
We will present the first constraints on axion-nucleon couplings derived from NuSTAR observations of Betelgeuse and discuss the potential insights that could be gained from detecting this line on the characteristic properties of Betelgeuse and similar supergiant stars. Our results establish significantly more stringent bounds than those obtained from solar observations for axion masses of m_a
$lesssim 10^{-10}$ eV.

Authors: RODRÍGUEZ CANDÓN, Francisco (Universidad de Zaragoza); RUZ ARMENDARIZ, Jaime (Lawrence Livermore Nat. Laboratory (US)); VOGEL, Julia Katharina (Universidad de Zaragoza (ES)); KALTSCHMIDT, Mathieu (CAPA, Universidad de Zaragoza); GIANNOTTI, Maurizio (Universidad de Zaragoza (ES)); CASASECA, Pablo (Universidad de Zaragoza)

Presenter: KALTSCHMIDT, Mathieu (CAPA, Universidad de Zaragoza)

Session Classification: Stars as Labs for Fundamental Physics

Contribution ID: **29**   Type: **Tests of LambdaCDM**

New robust constraints on Dark Photon Dark Matter from the intergalactic medium

Wednesday, 7 May 2025 15:04 (1 minute)

The ultralight dark photon is a well-motivated, hypothetical dark matter candidate. In a dilute plasma, they can resonantly convert into photons, and heat up the intergalactic medium between galaxies. In this talk, we explore the dark photon dark matter parameter space by comparing synthetic Lyman-α forest data from cosmological hydrodynamical simulations to observational data from VLT/UVES of the quasar HE0940-1050 (z = 3.09). We use a novel flux normalization technique that targets under-dense gas, reshaping the flux probability distribution. Not only do we place robust constraints on the kinetic mixing parameter of dark photon dark matter, but notably our findings suggest that this model can still reconcile simulated and observed Doppler parameter distributions of z ~ 0 Lyman-α lines, as seen by HST/COS. This work opens new pathways for the use of the Lyman-α forest to explore new physics, and can be extended to other scenarios such as primordial black hole evaporation, dark matter decay, and annihilation

Author: TROST, ANDREA (University of Trieste)

Co-authors: CAPUTO, Andrea (CERN); LIU, Hongwan; VIEL, Matteo (SISSA); CRISTIANI, Stefano

Presenter: TROST, ANDREA (University of Trieste)

Session Classification: LambdaCDM and beyond

Contribution ID: **32**   Type: **Pulsar Timing Arrays**

Explaining the PTA signal and dark matter with a conformal dark sector

Monday, 5 May 2025 15:03 (1 minute)

Strong first-order phase transitions offer a compelling explanation for the stochastic gravitational wave background in the nano-Hertz range measured by pulsar timing arrays (PTA). In this talk, I will consider a classically conformal dark sector in which the breaking of a dark U(1) gauge symmetry gives rise to a gravitational wave background that can fit the PTA data and additionally sources the mass of a stable fermionic sub-GeV dark matter candidate. The model is coupled to the Standard Model via a dark photon mediator which is tightly constrained by laboratory searches. I will discuss these accelerator constraints as well as cosmological constraints coming from the decay of dark Higgs bosons after the phase transition. Finally, I will present the results of a global fit and show that the model has viable parameter space where it fits the PTA data, reproduces the observed relic abundance and avoids all relevant constraints.

Author: TASILLO, Carlo (Uppsala University)

Co-authors: KAHLHOEFER, Felix (Karlsruhe Institute of Technology);   MATUSZAK, Jonas Armin (Albert Ludwigs Universitaet Freiburg (DE));   BALAN, Sowmiya (KIT);   BRINGMANN, Torsten (University of Oslo (NO))

Presenter: TASILLO, Carlo (Uppsala University)

Session Classification: Pulsar Timing Arrays

Contribution ID: 34

Type: **Tests of LambdaCDM**

Is cosmological data suggesting a nonminimal coupling between matter and gravity?

Wednesday, 7 May 2025 15:03 (1 minute)

We briefly present the late-time cosmological effects of a modified theory of gravity with a nonminimal coupling between curvature and matter. By evolving the cosmological parameters that match the cosmic microwave background data until their values from direct late-time measurements, we can obtain an agreement between different experimental methods without disrupting their individual validity. We use type Ia supernovae data from the Pantheon+ sample and the recent 5-year Dark Energy Survey (DES) data release along with baryon acoustic oscillation measurements from the Dark Energy Spectroscopic Instrument (DESI) and extended Baryon Oscillation Spectroscopic Survey (eBOSS) to constrain the modified model's parameters and to compare its fit quality to the Flat-ΛCDM model. We find moderate to strong evidence for a preference of the nonminimally coupled theory over the current standard model for all dataset combinations.

This talk is based on the work conducted in JCAP06(2024)025 (arXiv:2403.11683) and in Phys.Dark Univ. 48 (2025) 101861 (arXiv:2412.09348).

Author: BARROSO VARELA, Miguel

Presenter: BARROSO VARELA, Miguel

Session Classification: LambdaCDM and beyond

Contribution ID: **37**   Type: **Tests of LambdaCDM**

Anisotropy in Pantheon+ supernovae

Wednesday, 7 May 2025 15:01 (1 minute)

We employ Maximum Likelihood Estimators to examine the Pantheon+ catalogue of Type Ia supernovae for large scale anisotropies in the expansion rate of the Universe. The analyses are carried out in the heliocentric frame, the CMB frame, as well as the Local Group frame. In all frames, the Hubble expansion rate in the redshift range $0.023 < z < 0.15$ is found to have a statistically significant dipolar variation exceeding 1.5 km/s/Mpc, i.e. bigger than the claimed 1% uncertainty in the SH0ES measurement of the Hubble parameter H_0. The deceleration parameter too has a redshift-dependent dipolar modulation at >5 sigma significance, consistent with previous findings using the SDSSII/SNLS3 Joint Lightcurve Analysis catalogue. The inferred cosmic acceleration cannot therefore be due to a Cosmological Constant, but is probably an apparent (general relativistic) effect due to the anomalous bulk flow in our local Universe.

Author: Mr SAH, Animesh (Tata Institute of Fundamental Research)

Co-authors: TSAGAS, Christos (Aristotle University of Thessaloniki); Prof. SARKAR, Subir (University of Oxford); RAMEEZ, Mohamed (Tata Institute of Fundamental Research)

Presenter: Mr SAH, Animesh (Tata Institute of Fundamental Research)

Session Classification: LambdaCDM and beyond

Contribution ID: **39**   Type: **Tests of LambdaCDM**

New early dark energy and its equation of state

Wednesday, 7 May 2025 15:00 (1 minute)

The Hubble Tension is the discrepancy between the measured value of the Hubble parameter H_0 and its ΛCDM model prediction using CMB data. New Early Dark Energy (NEDE) addresses this tension using a triggered phase transition in the dark sector. In this work we constrain the properties of NEDE using recent datasets. We study the equation of state parameter, characterizing the post-phase transition fluid, allowing it to evolve in time. Our results indicate that data is compatible with a simple time dependence that could arise from a mixture of radiation and a stiff fluid. Our model shows a significant reduction of the tension down to below 3σ.

Author: CHATRCHYAN, Aleksandr (Nordita)

Co-authors: NIEDERMANN, Florian; Prof. SLOTH, Martin Snoager; Dr POULIN, Vivian (LUPM, CNRS & U. de Montpellier, France)

Presenter: CHATRCHYAN, Aleksandr (Nordita)

Session Classification: LambdaCDM and beyond

Contribution ID: **40**　　　　　　　　　　　　　　　　　　　Type: **Stars as Labs**

Probing Solar Heavy Neutrinos with Heliospheric Electrons

Tuesday, 6 May 2025 15:05 (1 minute)

We search for an excess of electrons and positrons in the interplanetary space from the decays of heavy neutrinos produced in nuclear reactions in the Sun. Using measurements of the electron spectra in the MeV range from the Ulysses and SOHO satellites, we report the strongest direct upper bound to date on the mixing between heavy neutral leptons with MeV masses and electron neutrinos, reaching $U_e^2 \, 10^{-6}$ at $M_N = 10$MeV. Our sensitivity is predominantly constrained by the uncertainties in the propagation of electrons and positrons, particularly the diffusion coefficient in the inner Solar System, as well as the uncertainties in the astrophysical background. Enhancing our understanding of either of these factors could lead to a significant improvement in sensitivity.

ArXiv : 2412.14752

Authors:　WEBER, Valentin;　DREWES, Marco;　HEISIG, Jan (RWTH Aachen University)

Presenter:　WEBER, Valentin

Session Classification:　Stars as Labs for Fundamental Physics

Contribution ID: **42**   Type: **Stars as Labs**

Constraints on asteroid-mass primordial black holes from capture by stars

Tuesday, 6 May 2025 15:03 (1 minute)

Primordial black holes (PBHs) in the asteroid-mass range remain a viable and until now unconstrained dark matter (DM) candidate. If these PBHs exist, they could be captured by stars in DM-dominated environments such as dwarf galaxies. The capture probability increases with the stellar mass, and captured PBHs would rapidly destroy their host stars. Using photometric observations from the Hubble Space Telescope, we use the non-observation of this destruction process to place constraints on the PBH abundance, and exclude asteroid-mass PBHs from making 100% of the DM at the 3.7σ level.

Refs: ArXiv 2207.07412, 2311.12658, 2503.03352

Authors: Mr ESSER, Nicolas; TINYAKOV, Peter (Universite Libre de Bruxelles)

Co-authors: Dr FILION, Carrie (Flatiron Institute); Dr RICHSTEIN, Hannah (University of Virginia); Prof. KALLIVAYALIL, Nitya (University of Virginia); Prof. WYSE, Rosemary (John Hopkins University); DE RIJCKE, Sven

Presenter: Mr ESSER, Nicolas

Session Classification: Stars as Labs for Fundamental Physics

Contribution ID: **43**   Type: **Pulsar Timing Arrays**

Scalar-induced gravitational waves with future PTA data

Monday, 5 May 2025 15:02 (1 minute)

The evidence for a stochastic gravitational wave background at nHz frequencies by Pulsar Timing Array (PTA) observations offers an opportunity to discover cosmological signals and threatens the observability of other subdominant gravitational waves (GWs). We explore prospects to constrain scalar-induced GWs associated with enhanced curvature perturbations in the primordial universe, forecasting realistic future PTA datasets. We assess how the currently observed signal could eventually limit future capabilities to search for GW relics of primordial phenomena and the associated phenomenological consequences, such as the formation of primordial black holes.

Authors: CECCHINI, Chiara (University of Trento, TIFPA-INFN); Mrs FRANCIOLINI, Gabriele; PIERONI, Mauro (CERN)

Presenter: CECCHINI, Chiara (University of Trento, TIFPA-INFN)

Session Classification: Pulsar Timing Arrays

Contribution ID: 45   Type: **Stars as Labs**

Dark Matter Scattering Constraints From Stars Surrounding Sgr A*

Tuesday, 6 May 2025 15:02 (1 minute)

Dark matter can be captured in stars and annihilate, providing the star with a new energy source in addition to nuclear fusion. This significantly changes stellar evolution at the Galactic Center, where the dark matter density is extremely high. As dark matter burning replaces nuclear fusion partially or completely, stars become longer-lived, as they use up hydrogen more conservatively, or even become immortal, as dark matter is re-supplied continuously. We show that this results in several prominent features that distinguish stellar populations in dark matter dense environments from populations without dark matter. This may offer an explanation for the unusually young stars at the Galactic Center, called the paradox of youth, as well as their top-heavy mass distribution. In some scenarios, the dark matter annihilation power can become so intense to disrupt star formation entirely, allowing us to derive constraints on dark matter-nucleon cross sections and density profiles based on stellar observations close to the Galactic Center.

Author: JOHN, Isabelle

Presenter: JOHN, Isabelle

Session Classification: Stars as Labs for Fundamental Physics

Contribution ID: **47**   Type: **Pulsar Timing Arrays**

Binary Pulsars Hunting Ultra-light Dark Matter

Monday, 5 May 2025 15:05 (1 minute)

Ultra-light dark matter (ULDM) is a promising candidate for cosmological dark matter. If ULDM exists and interacts directly with ordinary matter, it could produce characteristic signals in the timing data of pulsars in binary systems.

In this talk, we review the latest results on how binary pulsars can constrain the ULDM parameter space through pulsar timing data and signal modeling. Our analysis employs two independent methods: (1) Bayesian model comparison and (2) deep neural networks. We compare the strengths and weaknesses of each approach, present the sensitivity limits they yield, and discuss prospects for future research.

Author: KŮS, Pavel

Presenter: KŮS, Pavel

Session Classification: Pulsar Timing Arrays

Contribution ID: **49**   Type: **Pulsar Timing Arrays**

SMBH in light of the PTA background

Monday, 5 May 2025 15:00 (1 minute)

In this talk, I will introduce our work interpreting the PTA background as originating from SMBH binaries. Focusing on its interesting statistical properties, the implications for the environmental effects, possible eccentricity signatures and anisotropies in the background that could lead to differentiate it from a cosmological source.

Author: URRUTIA, Juan (KBFI)

Presenter: URRUTIA, Juan (KBFI)

Session Classification: Pulsar Timing Arrays

Contribution ID: **52**   Type: **Pulsar Timing Arrays**

Detecting gravitational wave anisotropies from supermassive black hole binaries

Monday, 5 May 2025 15:01 (1 minute)

Anisotropies play a central role in distinguishing between cosmological and astrophysical sources of the GWB, as detectable anisotropies are expected for a GWB from a population of supermassive black hole binaries (SMBHBs) but not for cosmological sources. We perform searches for anisotropies on simulated PTA datasets, showing that null detections for anisotropies in both current and near-future data releases are consistent with a GWB sourced by SMBHBs. Additionally, we identify regions of the SMBHB parameter space that are more likely to result in detectable levels of anisotropies

Authors: MITRIDATE, Andrea; LEMKE, Anna-Malin; GERSBACH, Kyle A.

Presenter: LEMKE, Anna-Malin

Session Classification: Pulsar Timing Arrays

Contribution ID: **55**   Type: **Tests of LambdaCDM**

Generalised Neutrino Isocurvature

Wednesday, 7 May 2025 15:05 (1 minute)

While searches for neutrino isocurvature usually constrain a specific linear combination of isocurvature perturbations, this talk focusses on realistic cosmological scenarios giving rise to neutrino isocurvature - mostly in the form of dark radiation. In general both, neutrino and dark matter isocurvature perturbations are generated, whose ratio can be parameterised by a newly introduced mixing angle. The talk will discuss first limits on this new mixing angle from PLANCK data, as well as novel insights into the early Universe that could be provided by future measurements.

Authors: GERLACH, Christopher (Johannes Gutenberg-Universität Mainz); SCHWALLER, Pedro; RATZINGER, Wolfram (Weizmann Institute)

Presenter: GERLACH, Christopher (Johannes Gutenberg-Universität Mainz)

Session Classification: LambdaCDM and beyond

Contribution ID: **60**   Type: **Tests of LambdaCDM**

Inferring cosmological parameters from galaxy and dark sirens cross-correlation

Wednesday, 7 May 2025 15:02 (1 minute)

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 constrains on cosmological parameters like H_0.

Author: SALA, Giona (RWTH Aachen University)

Co-authors: VALBUSA DALL'ARMI, Lorenzo; LESGOURGUES, Julien (TTK, RWTH Aachen University); CUOCO, Alessandro; Mr REVIS, Kostantinos (RWTH Aachen)

Presenter: SALA, Giona (RWTH Aachen University)

Session Classification: LambdaCDM and beyond

Contribution ID: **61**   Type: **Pulsar Timing Arrays**

To log or not to log: NANOGrav bounds on the tension of stable cosmic strings

Monday, 5 May 2025 15:04 (1 minute)

In the NANOGrav 15-year New Physics analysis (arXiv:2306.16219), a log-uniform prior on $G\mu$ was imposed to determine upper limits on the tension of stable cosmic strings. Here, we examine the prior dependence of this bound through comparison with new upper limits obtained using a uniform prior on $G\mu$. New posterior distributions and upper limits on stable cosmic string tension were calculated using semi-analytic and numerical (MCMC) methods, and show that the 95% bounds are robust against the prior choice, up to variations within a factor of 1.5 or so. We also compare the cosmic string model with a log-uniform prior and the same model with a uniform prior in terms of the associated Bayes factor. At face value, this Bayes factor seems to indicate a preference for a uniform prior choice; however, upon closer inspection, it serves as an illustration of the underlying sensitivity to prior volume effects.

Authors: SCHMITZ, Kai (Universität Münster (DE));   BITCON, Olivia (Institute for Theoretical Physics - University of Münster);   SCHRÖDER, Tobias (University of Münster)

Presenter: BITCON, Olivia (Institute for Theoretical Physics - University of Münster)

Session Classification: Pulsar Timing Arrays

Contribution ID: **62**   Type: **Stars as Labs**

Probing Heavy Axion-like Particles from Massive Stars with X-rays and Gamma Rays

Tuesday, 6 May 2025 15:01 (1 minute)

The hot interiors of massive stars in the later stages of their evolution provide an ideal place for the production of heavy axion-like particles (ALPs) with mass up to O(100 keV) range. We show that a fraction of these ALPs could stream out of the stellar photosphere and subsequently decay into two photons that can be potentially detected on or near the Earth. In particular, we estimate the photon flux originating from the spontaneous decay of heavy ALPs produced inside Horizontal Branch and Wolf-Rayet stars, and assess its detectability by current and future X-ray and gamma-ray telescopes. Our results indicate that current and future telescopes can probe axion-photon couplings down to $g_{a\gamma} \sim 4 \times 10^{-11}$ GeV^{-1} for $m_a \sim 10 - 100$ keV, which covers new ground in the ALP parameter space.

Author: OKAWA, Takuya

Co-authors: DEV, Bhupal (Washington University in St. Louis);   FERRER, Francesc (Washington University in St Louis);   BUCKLEY, James (Washington University in St. Louis)

Presenter: OKAWA, Takuya

Session Classification: Stars as Labs for Fundamental Physics

Contribution ID: **63**   Type: **Stars as Labs**

Identifying the necessary conditions for fast neutrino flavor conversion in core-collapse supernovae

Tuesday, 6 May 2025 15:04 (1 minute)

Neutrinos, despite their weak interactions, play an important role in core-collapse supernova evolution. In the supernova core, the neutrino number density is so high that the coherent forward scattering among neutrinos leads to flavor conversion, a phenomenon that can alter both the supernova explosion dynamics and nucleosynthesis. In this talk, I will discuss how to identify the necessary conditions for fast neutrino flavor conversion in core-collapse supernova simulations, and how they are affected by the presence of muons and convection.

Author: CORNELIUS, Marie (Niels Bohr Institute, University of Copenhagen)

Co-author: TAMBORRA, Irene (Niels Bohr Institute)

Presenter: CORNELIUS, Marie (Niels Bohr Institute, University of Copenhagen)

Session Classification: Stars as Labs for Fundamental Physics

Contribution ID: **67**   Type: **not specified**

Questions & discussion

Monday, 5 May 2025 15:07 (23 minutes)

Session Classification: Pulsar Timing Arrays

Contribution ID: **68**   Type: **not specified**

Questions and Discussion

Wednesday, 7 May 2025 15:06 (24 minutes)

Session Classification: LambdaCDM and beyond