9th LISA Cosmology Working Group Workshop

Rapport sur les contributions

https://indico.in2p3.fr/e/25520

ID de Contribution: **2** Type: **Non spécifié**

Status of Bouncing Cosmology and possible observations with LISA

We discuss the status of Bouncing Cosmology models and their predictions for LISA. Specific emphasis will be given for models with sourced fluctuations that may be observed by several probes.

Author: BEN-DAYAN, Ido (BGU (Ben Gurion University))

Co-auteur: THATTARAMPILLY, Udaykrishnna (Ariel University)

Orateurs: BEN-DAYAN, Ido (BGU (Ben Gurion University)); THATTARAMPILLY, Udaykrishnna (Ariel University)

ID de Contribution: **3** Type: **Non spécifié**

Turbulent production of polarized gravitational radiation from primordial helical magnetic fields

The generation of primordial magnetic fields and its interaction with the primordial plasma during cosmological phase transitions is turbulent in nature. I will describe and discuss results of direct numerical simulations of magnetohydrodynamic (MHD) turbulence in the early universe and the resulting stochastic gravitational wave background (SGWB). In addition to the SGWB, the primordial magnetic field will evolve up to our present time and its relics can explain indirect observations of weak magnetic fields coherent on very large scales. I will focus on magnetic fields produced at the electroweak phase transition and show that these signals may be detectable by LISA. Such detections could lead to the understanding of the underlying physics of cosmological phase transitions, which can have consequences on the baryon asymmetry problem and on the origin seed of observed magnetic fields coherent over very large scales at the present time. In particular, I will present the impact of helicity in primordial magnetic fields on the generation of polarized GW backgrounds and the efforts to detect this polarization by using a network of space-based GW detectors, as LISA and Taiji; see https://arxiv.org/abs/2107.05356.

Author: ROPER POL, Alberto (APC)

Orateur: ROPER POL, Alberto (APC)

ID de Contribution: **4** Type: **Non spécifié**

Primordial gravitational-waves boosted by the axion

This talk focuses on a matter-kination era that can occur naturally inside the standard radiation era due to axion dynamics. The matter-kination era imprints a smoking-gun GW peak on the irreducible inflationary GW background as well as on the local/global cosmic-string GW background, whose position depends on kination's energy scale and duration. Remarkably, the viable parameter space allows for a kination era at the MeV-EeV scale and generates a GW peak which lies inside LISA, as well as ET, and CE sensitivity windows. We connect the matter-kination peak to the abundance of axion dark matter.

Authors: SERVANT, Geraldine (CERN); SIMAKACHORN, Peera (Universität Hamburg and DESY); Dr GOUTTENOIRE, Yann (Tel Aviv University)

Orateur: SIMAKACHORN, Peera (Universität Hamburg and DESY)

ID de Contribution: **5** Type: **Non spécifié**

Electroweak bubble wall expansion: gravitational waves and baryogenesis in Standard Model-like thermal plasma

Computing the properties of the bubble wall of a cosmological first order phase transition at electroweak scale is of paramount importance for the correct prediction of the baryon asymmetry of the universe and the spectrum of gravitational waves. By means of the semi-classical formalism we calculate the velocity and thickness of the wall using as theoretical framework the scalar singlet extension of the SM with a parity symmetry and the SM effective field theory supplemented by a dimension six operator. We use these solutions to carefully predict the baryon asymmetry and the gravitational wave signals. The singlet scenario can easily accommodate the observed asymmetry but these solutions do not lead to observable effects at future gravity wave experiments. In contrast the effective field theory fails at explaining the baryon abundance due to the strict constraints from electric dipole moment experiments, however, the strongest solutions we found fall within the sensitivity of the LISA experiment. We provide a simple analytical approximation for the wall velocity which only requires calculation of the strength and temperature of the transition and works reasonably well in all models tested. We find that generically the weak transitions where the fluid approximation can be used to calculate the wall velocity and verify baryogenesis produce signals too weak to be observed in future gravitational wave experiments. Thus, we infer that GW signals produced by simple SM extensions visible in future experiments are likely to only be produced in strong transitions described by detonations with highly relativistic wall velocities.

Author: MERCHAND MEDINA, Marco Antonio (University of Warsaw)

Orateur: MERCHAND MEDINA, Marco Antonio (University of Warsaw)

ID de Contribution: **6** Type: **Non spécifié**

Status of the LISA mission

mercredi 8 décembre 2021 15:00 (30 minutes)

Orateurs: PETITEAU, Antoine (APC - Université Paris-Diderot); HEWITSON, Martin (AEI Hannover)

Classification de Session: LISA CosWG Workshop day 1

ID de Contribution: **7** Type: **Non spécifié**

LSG activities and Working Packages

mercredi 8 décembre 2021 15:30 (30 minutes)

Orateur: GAIR, Jon

Classification de Session: LISA CosWG Workshop day 1

ID de Contribution: **8** Type: **Non spécifié**

Overview of LISA astrophysics WG white paper

mercredi 8 décembre 2021 16:00 (25 minutes)

Orateur: MARTA, Volonteri

Classification de Session: LISA CosWG Workshop day 1

ID de Contribution: **9** Type: **Non spécifié**

Overview of LISA waveform WG white paper

mercredi 8 décembre 2021 16:25 (25 minutes)

Orateur: HELVI, Witek

Classification de Session: LISA CosWG Workshop day 1

ID de Contribution: **10** Type: **Non spécifié**

Tools from the LDC and how to get involved

mercredi 8 décembre 2021 17:30 (30 minutes)

Orateur: BAGHI, Quentin (NASA GSFC - USRA)

Classification de Session: LISA CosWG Workshop day 1

ID de Contribution: **11** Type: **Non spécifié**

Contributed talks

Classification de Session: LISA CosWG Workshop day 1

ID de Contribution: **12** Type: **Non spécifié**

Contributed talks

Classification de Session: LISA CosWG Workshop day 2

ID de Contribution: **13** Type: **Non spécifié**

CosWG projects updates

jeudi 9 décembre 2021 16:20 (30 minutes)

Orateurs: RICCIARDONE, Angelo (INFN - Padova); NARDINI, Germano (University of Stavanger); TASINATO, Gianmassimo (Swansea Uni); GARCIA-BELLIDO, Juan; CLESSE, Sebastien (Université Libre de Bruxelles (ULB), Brussels); BAKER, Tessa

Classification de Session: LISA CosWG Workshop day 2

ID de Contribution: **14** Type: **Non spécifié**

Discussion on CosWG projects rules and procedures

jeudi 9 décembre 2021 17:20 (1 heure)

Classification de Session: LISA CosWG Workshop day 2

ID de Contribution: **15** Type: **Non spécifié**

Contributed talks

Classification de Session: LISA CosWG Workshop day 2

ID de Contribution: **16** Type: **Non spécifié**

Bridging the µHz gap in the gravitational-wave landscape with binary resonance

The passage of gravitational waves (GWs) through a binary perturbs the trajectories of the two bodies, potentially causing observable changes to their orbital parameters. In the presence of a stochastic GW background (SGWB) these changes accumulate over time, causing the binary orbit to execute a random walk through parameter space. In this talk I will present a powerful new formalism for calculating the full statistical evolution of a generic binary system in the presence of a SGWB, capturing all six of the binary's orbital parameters. I will show how this formalism can be used to set novel upper limits on the SGWB spectrum in the μHz frequency band, between the regions probed by LISA and pulsar timing arrays. As examples of the discovery potential of these methods, I will show how they are able to probe GWs from cosmological phase transitions in a region of parameter space that is inaccessible with LISA and other experiments, and will discuss how they might shed light on the possible SGWB signal detected by NANOGrav.

Author: JENKINS, Alex (King's College London)

Co-auteur: BLAS, Diego

Orateur: JENKINS, Alex (King's College London)

ID de Contribution: **17** Type: **Non spécifié**

Gravitational waves from bubble collisions in first order phase transitions

We will discuss energy budget of first order phase transitions and identify models capable of supporting extreme supercooling necessary to feature bubble collisions as the main source of gravitational waves. We will also review new semi-analytical calculation of the spectrum appropriate in such strong transitions.

Author: LEWICKI, Marek (University of Warsaw)

Orateur: LEWICKI, Marek (University of Warsaw)

ID de Contribution: **18** Type: **Non spécifié**

Impact of LIGO-Virgo binaries on gravitational wave background searches

The merger rate of $\mathcal{O}(10M_\odot)$ black holes inferred from the LIGO-Virgo observations indicates that these binaries generate a sizeable gravitational wave foreground. In this talk I will present a simple analysis quantifying the impact of this foreground on the detectability of the primordial gravitational wave background by future gravitational wave experiments.

Authors: Dr VASKONEN, Ville (IFAE); Dr LEWICKI, Marek (University of Warsaw)

Orateur: Dr VASKONEN, Ville (IFAE)

ID de Contribution: **19** Type: **Non spécifié**

Gravitational waves from first-order phase transitions: A hybrid simulation, and signal enhancement from density perturbations

Over the next few decades, we will have an exciting opportunity to detect GWs from the early Universe with space interferometers. In this talk, we first propose a new numerical scheme to calculate GWs from sound waves in first-order phase transitions, which reveals more detailed structure of the spectrum. Based on this simulation, we next discuss the possibility of the enhancement of the GW signal in the presence of density perturbations. The first part is based on 2010.00971 with T. Konstandin and H.Rubira (DESY), while the second part is based on 2108.11947 with T. Konstandin, H. Rubira, and J. van de Vis (DESY).

Authors: Dr RUBIRA, Henrique (DESY); Dr VAN DE VIS, Jorinde (DESY); Prof. KONSTANDIN, Thomas (DESY); JINNO, Ryusuke (Instituto de Física Teórica)

Orateur: JINNO, Ryusuke (Instituto de Física Teórica)

ID de Contribution: **20** Type: **Non spécifié**

Oscillations in the stochastic gravitational wave background

Observational constraints and prospects for detection of features, i.e. physically motivated oscillations in the primordial power spectrum, have so far concentrated on the CMB and Large Scale Structure surveys. These oscillations are induced by transient non-adiabatic dynamics along the inflationary history that generate a burst of particle production during inflation.
I will show how features lead to characteristic oscillatory patterns in the stochastic gravitational wave background (SGWB) for which we derive explicit (semi-)analytical templates.
The SGWB sourced during inflation can overcome the standard scalar-induced SGWB sourced at horizon re-entry of the fluctuations after inflation, while being less constrained by perturbativity and backreaction bounds. In addition, one may entertain the possibility of detecting both signals since they peak at different frequencies exhibiting oscillations with distinct periods.

Authors: FUMAGALLI, Jacopo (IAP); WITKOWSKI, Lukas (IAP); RENAUX-PETEL, Sébastien (IAP-CNRS)

Orateur: FUMAGALLI, Jacopo (IAP)

ID de Contribution: **21** Type: **Non spécifié**

Extreme Mass-Ratio Inspirals as dark standard sirens

In this talk we discuss the potential of Extreme Mass-Ratio Inspirals (EMRIs) observed by LISA as dark standard sirens by cross-matching their sky localisation region with mock galaxy catalogs, i.e., statistically inferring the galaxy host redshift. We report constraints on the cosmological parameters assuming either a ΛCDM model or a redshift-evolving dark energy equation of state, showing that EMRIs will be excellent probes of the Hubble parameter H_0 and, potentially, also of the first-order dark energy equation-of-state parameter w_0.

Author: LAGHI, Danny (L2I Toulouse, CNRS/IN2P3)

Orateur: LAGHI, Danny (L2I Toulouse, CNRS/IN2P3)

ID de Contribution: **22** Type: **Non spécifié**

Multi-band gravitational wave cosmology with stellar origin black hole binaries

Massive stellar origin black hole binaries, originating from stars above the pair-instability mass gap, are primary candidate for multi-band gravitational wave observations. In this talk we show the possibility to use them as effective dark standard sirens to constrain cosmological parameters, with a particular focus on the Hubble constant H_0. The long lasting inspiral signal emitted by these systems is accessible by LISA, while the late inspiral and merger are eventually detected by third generation ground-based telescopes such as the Einstein Telescope. The direct measurement of the luminosity distance and the sky position of the source, together with the inhomogeneous redshift distribution of possible host galaxies, allow to infer cosmological parameters by probabilistic means. The efficiency of this statistical method relies in high parameter estimation performances, and we show that this multi-band approach allows a precise determination of the Hubble constant.

Author: MUTTONI, Niccolò (L2IT Toulouse, CNRS/IN2P3)

Orateur: MUTTONI, Niccolò (L2IT Toulouse, CNRS/IN2P3)

Classification de Session: LISA CosWG Workshop day 2

ID de Contribution: **23** Type: **Non spécifié**

CosWG projects updates

jeudi 9 décembre 2021 17:05 (15 minutes)

Orateurs: RICCIARDONE, Angelo (INFN - Padova); NARDINI, Germano (University of Stavanger); TASINATO, Gianmassimo (Swansea Uni); GARCIA-BELLIDO, Juan; CLESSE, Sebastien (Université Libre de Bruxelles (ULB), Brussels); BAKER, Tessa

Classification de Session: LISA CosWG Workshop day 2

ID de Contribution: **24** Type: **Non spécifié**

Overview of LISA Fundamental Physics white paper

mercredi 8 décembre 2021 17:05 (25 minutes)

Orateur: DONEVA, Daniela

Classification de Session: LISA CosWG Workshop day 1

ID de Contribution: **25** Type: **Non spécifié**

Stochastic GW background mapping

jeudi 9 décembre 2021 15:40 (20 minutes)

Orateur: VUK, Mandic

Classification de Session: LISA CosWG Workshop day 2

ID de Contribution: **26** Type: **Non spécifié**

Review of new LVK cosmology results from O3

jeudi 9 décembre 2021 15:00 (20 minutes)

Orateur: MASTROGIOVANNI, Simone

Classification de Session: LISA CosWG Workshop day 2

ID de Contribution: **27** Type: **Non spécifié**

Extreme Mass-Ratio Inspirals as dark standard sirens

jeudi 9 décembre 2021 15:20 (10 minutes)

Orateur: LAGHI, Danny (L2I Toulouse, CNRS/IN2P3)

Classification de Session: LISA CosWG Workshop day 2

ID de Contribution: **28** Type: **Non spécifié**

Multi-band gravitational wave cosmology with stellar origin black hole binaries

jeudi 9 décembre 2021 15:30 (10 minutes)

Orateur: MUTTONI, Niccolò (L2IT Toulouse, CNRS/IN2P3)

Classification de Session: LISA CosWG Workshop day 2

ID de Contribution: **29** Type: **Non spécifié**

Nonperturbative quantization of gravitational waves, and their signatures: a model

We consider the polymer quantization of gravitational waves propagating on a classical cosmological background. The model is flexible in the sense that the background can be chosen to be FLRW, flat. etc. Using this model, we study some of the observational signatures associated with quantum gravity imprinted on such gravitational waves. These include the modification to the dispersion relation, propagation speed and the waveform of the waves. Furthermore, since the classical Hamiltonian of the waves is time-dependent due to the presence of the scale factor, it was unclear how to polymer quantize such a Hamiltonian up until now. To overcome this, we use a novel method, involving the extended phase space, to quantize the system and derive the effective Hamiltonian. To our knowledge, this is the first time this method has been applied to the gravitational waves Hamiltonian.

Author: RASTGOO, Saeed

Orateur: RASTGOO, Saeed

ID de Contribution: **30** Type: **Non spécifié**

Primordial gravitational-waves boosted by the axion

mercredi 8 décembre 2021 18:00 (10 minutes)

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Orateur: SIMAKACHORN, Peera (Universität Hamburg and DESY)

Classification de Session: LISA CosWG Workshop day 1

ID de Contribution: **31** Type: **Non spécifié**

Oscillations in the stochastic gravitational wave background from particle production during inflation

mercredi 8 décembre 2021 18:10 (10 minutes)

Observational constraints and prospects for detection of features, i.e. physically motivated oscillations in the primordial power spectrum, have so far concentrated on the CMB and Large Scale Structure surveys. These oscillations are induced by transient non-adiabatic dynamics along the inflationary history that generate a burst of particle production during inflation.
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Orateur: FUMAGALLI, Jacopo (IAP)

Classification de Session: LISA CosWG Workshop day 1

ID de Contribution: **32** Type: **Non spécifié**

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Orateur: BEN-DAYAN, Ido (BGU (Ben Gurion University))

Classification de Session: LISA CosWG Workshop day 1

ID de Contribution: **33** Type: **Non spécifié**

Bridging the μHz gap in the gravitational-wave landscape with binary resonance

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The passage of gravitational waves (GWs) through a binary perturbs the trajectories of the two bodies, potentially causing observable changes to their orbital parameters. In the presence of a stochastic GW background (SGWB) these changes accumulate over time, causing the binary orbit to execute a random walk through parameter space. In this talk I will present a powerful new formalism for calculating the full statistical evolution of a generic binary system in the presence of a SGWB, capturing all six of the binary's orbital parameters. I will show how this formalism can be used to set novel upper limits on the SGWB spectrum in the ⊠Hz frequency band, between the regions probed by LISA and pulsar timing arrays. As examples of the discovery potential of these methods, I will show how they are able to probe GWs from cosmological phase transitions in a region of parameter space that is inaccessible with LISA and other experiments, and will discuss how they might shed light on the possible SGWB signal detected by NANOGrav.

Orateur: JENKINS, Alex (King's College London)

Classification de Session: LISA CosWG Workshop day 1

ID de Contribution: **34** Type: **Non spécifié**

Impact of LIGO-Virgo binaries on gravitational wave background searches

mercredi 8 décembre 2021 18:40 (10 minutes)

The merger rate of 𝒪(10𝒪𝒪) black holes inferred from the LIGO-Virgo observations indicates that these binaries generate a sizeable gravitational wave foreground. In this talk I will present a simple analysis quantifying the impact of this foreground on the detectability of the primordial gravitational wave background by future gravitational wave experiments.

Orateur: VASKONEN, Ville (IFAE)

Classification de Session: LISA CosWG Workshop day 1

ID de Contribution: **35** Type: **Non spécifié**

Nonperturbative quantization of gravitational waves, and their signatures: a model

mercredi 8 décembre 2021 18:50 (10 minutes)

We consider the polymer quantization of gravitational waves propagating on a classical cosmological background. The model is flexible in the sense that the background can be chosen to be FLRW, flat. etc. Using this model, we study some of the observational signatures associated with quantum gravity imprinted on such gravitational waves. These include the modification to the dispersion relation, propagation speed and the waveform of the waves. Furthermore, since the classical Hamiltonian of the waves is time-dependent due to the presence of the scale factor, it was unclear how to polymer quantize such a Hamiltonian up until now. To overcome this, we use a novel method, involving the extended phase space, to quantize the system and derive the effective Hamiltonian. To our knowledge, this is the first time this method has been applied to the gravitational waves Hamiltonian.

Orateur: RASTGOO, Saeed

Classification de Session: LISA CosWG Workshop day 1

ID de Contribution: **36** Type: **Non spécifié**

The recent excess noise observed by PTAs

jeudi 9 décembre 2021 16:00 (20 minutes)

Orateur: CORNISH, Neil

Classification de Session: LISA CosWG Workshop day 2

ID de Contribution: **37** Type: **Non spécifié**

Turbulent production of polarized gravitational radiation from primordial helical magnetic fields

jeudi 9 décembre 2021 18:20 (10 minutes)

The generation of primordial magnetic fields and its interaction with the primordial plasma during cosmological phase transitions is turbulent in nature. I will describe and discuss results of direct numerical simulations of magnetohydrodynamic (MHD) turbulence in the early universe and the resulting stochastic gravitational wave background (SGWB). In addition to the SGWB, the primordial magnetic field will evolve up to our present time and its relics can explain indirect observations of weak magnetic fields coherent on very large scales. I will focus on magnetic fields produced at the electroweak phase transition and show that these signals may be detectable by LISA. Such detections could lead to the understanding of the underlying physics of cosmological phase transitions, which can have consequences on the baryon asymmetry problem and on the origin seed of observed magnetic fields coherent over very large scales at the present time. In particular, I will present the impact of helicity in primordial magnetic fields on the generation of polarized GW backgrounds and the efforts to detect this polarization by using a network of space-based GW detectors, as LISA and Taiji; see https://arxiv.org/abs/2107.05356.

Orateur: ROPER POL, Alberto (APC)

Classification de Session: LISA CosWG Workshop day 2

ID de Contribution: **38** Type: **Non spécifié**

Gravitational waves from first-order phase transitions: A hybrid simulation, and signal enhancement from density perturbations

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Over the next few decades, we will have an exciting opportunity to detect GWs from the early Universe with space interferometers. In this talk, we first propose a new numerical scheme to calculate GWs from sound waves in first-order phase transitions, which reveals more detailed structure of the spectrum. Based on this simulation, we next discuss the possibility of the enhancement of the GW signal in the presence of density perturbations. The first part is based on 2010.00971 with T. Konstandin and H.Rubira (DESY), while the second part is based on 2108.11947 with T. Konstandin, H. Rubira, and J. van de Vis (DESY).

Orateur: JINNO, Ryusuke (Instituto de Física Teórica)

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We will discuss energy budget of first order phase transitions and identify models capable of supporting extreme supercooling necessary to feature bubble collisions as the main source of gravitational waves. We will also review new semi-analytical calculation of the spectrum appropriate in such strong transitions.

Orateur: LEWICKI, Marek (University of Warsaw)

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Computing the properties of the bubble wall of a cosmological first order phase transition at electroweak scale is of paramount importance for the correct prediction of the baryon asymmetry of the universe and the spectrum of gravitational waves. By means of the semi-classical formalism we calculate the velocity and thickness of the wall using as theoretical framework the scalar singlet extension of the SM with a parity symmetry and the SM effective field theory supplemented by a dimension six operator. We use these solutions to carefully predict the baryon asymmetry and the gravitational wave signals. The singlet scenario can easily accommodate the observed asymmetry but these solutions do not lead to observable effects at future gravity wave experiments. In contrast the effective field theory fails at explaining the baryon abundance due to the strict constraints from electric dipole moment experiments, however, the strongest solutions we found fall within the sensitivity of the LISA experiment. We provide a simple analytical approximation for the wall velocity which only requires calculation of the strength and temperature of the transition and works reasonably well in all models tested. We find that generically the weak transitions where the fluid approximation can be used to calculate the wall velocity and verify baryogenesis produce signals too weak to be observed in future gravitational wave experiments. Thus, we infer that GW signals produced by simple SM extensions visible in future experiments are likely to only be produced in strong transitions described by detonations with highly relativistic wall velocities.

Orateur: MERCHAND MEDINA, Marco Antonio (University of Warsaw)

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