

**KEK Cosmo 2025**

# **Report of Contributions**

Contribution ID: 1

Type: **not specified**

# Quantum measurement and Bell inequality 1

*Monday, 2 March 2026 10:00 (2 hours)*

**Presenter:** TSUTSUI, Izumi

**Session Classification:** Lectures Session I

Contribution ID: 2

Type: **not specified**

# Cosmological Tensions 1

*Monday, 2 March 2026 13:00 (2 hours)*

**Presenter:** CHEN, Shi-Fan

**Session Classification:** Lectures Session II

Contribution ID: 3

Type: **not specified**

# Pulsar Timing Arrays 1

*Monday, 2 March 2026 15:30 (2 hours)*

**Primary author:** NISHIZAWA, Atsushi

**Presenter:** NISHIZAWA, Atsushi

**Session Classification:** Lectures Session III

Contribution ID: 4

Type: **not specified**

## Quantum measurement and Bell inequality 2

*Tuesday, 3 March 2026 09:50 (2 hours)*

**Primary author:** TSUTSUI, Izumi

**Presenter:** TSUTSUI, Izumi

**Session Classification:** Lectures Session I

Contribution ID: 5

Type: **not specified**

## **Cosmological Tensions 2**

*Tuesday, 3 March 2026 12:45 (2 hours)*

**Presenter:** CHEN, Shi-Fan

**Session Classification:** Lectures Session II

Contribution ID: 6

Type: **not specified**

## **Pulsar Timing Arrays 2**

*Tuesday, 3 March 2026 15:10 (2 hours)*

**Presenter:** NISHIZAWA, Atsushi

**Session Classification:** Lectures Session III

Contribution ID: 7

Type: **not specified**

# The BAO-CMB Tension and Implications for Inflation

*Wednesday, 4 March 2026 09:10 (1 hour)*

**Presenter:** FERREIRA, Elisa

**Session Classification:** Opening & Session I

Contribution ID: 8

Type: **not specified**

## Quantum and classical properties of interacting primordial inhomogeneities

*Wednesday, 4 March 2026 10:10 (20 minutes)*

The statistical properties of the Cosmic Microwave Background (CMB) anisotropies, which reflect the curvature inhomogeneities of the early Universe, are well-accounted for by assuming that these inhomogeneities emerged from amplified vacuum fluctuations. As they result from a genuine quantum process, it is natural to question which properties of these primordial inhomogeneities are inherently quantum and which, if any, have persisted until their observation despite interactions that induced decoherence, thereby rendering them classical. I will review the latest progress on these questions. References: Martin, J., Micheli, A., & Vennin, V. (2022). Discord and decoherence. *Journal of Cosmology and Astroparticle Physics*, 2022(04), 051. Micheli, A., & Peter, P. (2023). Quantum Cosmological Gravitational Waves? In C. Bambi, L. Modesto, & I. Shapiro (Eds), *Handbook of Quantum Gravity* (pp. 1-66) Micheli, A., Oshima, Y., & Takahashi, T. (2025) Squeezing of cosmological perturbations in presence of decoherence, in preparation

**Primary author:** MICHELI, Amaury**Presenter:** MICHELI, Amaury**Session Classification:** Opening & Session I

Contribution ID: 9

Type: **not specified**

## Quantum Nature of Primordial Gravitational Waves in Hořava-Lifshitz Gravity

*Wednesday, 4 March 2026 10:30 (20 minutes)*

Hořava-Lifshitz (HL) gravity generates scale-invariant primordial density fluctuations and gravitational waves (PGWs) without requiring inflation. We investigate the quantum nature of PGWs within HL gravity. While inflationary models suggest the non-classicality (squeezed coherent state) of PGWs might be detectable via Hanbury Brown-Twiss (HBT) interferometry, we explore this possibility in the HL framework. We demonstrate that scale-invariant PGWs are produced during both the radiation-dominated and matter-dominated eras of the Universe within HL cosmology. Furthermore, we show that the frequency range exhibiting detectable quantum signatures for these HL-generated PGWs significantly exceeds that predicted by standard inflationary models. This extended range potentially enhances prospects for observing the quantum nature of gravity through future interferometric observations of PGWs.

**Primary author:** MATSUI, Hiroki

**Presenter:** MATSUI, Hiroki

**Session Classification:** Opening & Session I

Contribution ID: 10

Type: **not specified**

## The Imprints of Primordial Non- Gaussianity on the Scalar-Induced Gravitational-Wave Background

*Wednesday, 4 March 2026 10:50 (20 minutes)*

Scalar-induced gravitational waves (SIGWs) are produced nonlinearly by enhanced curvature perturbations and serve as a promising probe of primordial non-Gaussianity (PNG) in the early Universe. In this talk, I will present our systematic study of local-type PNG imprints on the SIGW background. I will introduce a “renormalized” diagrammatic approach we developed, which simplifies calculations of the SIGW energy-density spectrum for high-order PNG and enables analysis up to arbitrary order. Using this framework, we study the key spectra that describe different aspects of the SIGW background: the energy-density fraction spectrum for isotropic component, the angular power spectrum for anisotropies, and the angular bispectrum and trispectrum for non-Gaussianity. Focusing on PNG up to quartic order ( $h_{\text{NL}}$  order), our numerical results demonstrate that PNG can significantly enhance the SIGW energy density and generate distinctive anisotropic and non-Gaussian signatures. These findings highlight the potential of the SIGW background as a sensitive probe of primordial physics.

**Primary author:** LI, Jun- Peng**Presenter:** LI, Jun- Peng**Session Classification:** Opening & Session I

Contribution ID: 11

Type: **not specified**

# Quantum Algorithm for the Fokker-Planck Equation in Cosmology

*Wednesday, 4 March 2026 11:10 (20 minutes)*

In this talk, we present a quantum algorithm for numerically solving the Fokker-Planck equation that describes the stochastic processes in cosmology. In particular, we consider the discretization in which time evolution is represented via (sub-)stochastic transition matrices. Based on this discretization, the computation of time evolution of the numerical solution to the Fokker-Planck equation becomes repeated multiplication of the transition matrices, suggesting the possibility of an implementation via quantum algorithms. We present a method to implement this repeated matrix multiplication using a quantum matrix inversion algorithm [1] based on Quantum Singular Value Transformation (QSVT) [2]. As an application, we demonstrate how this method can be used to analyze the phase transition to eternal inflation in cosmic inflation [3].

**Presenter:** LEONG, Hou Heng

**Session Classification:** Opening & Session I

Contribution ID: 12

Type: **not specified**

## **Frontiers of CMB measurements and cosmological tests of Bell inequality**

*Wednesday, 4 March 2026 13:00 (1 hour)*

**Primary author:** CHINONE, Yuji

**Presenter:** CHINONE, Yuji

**Session Classification:** Session II

Contribution ID: 13

Type: **not specified**

## Towards the prediction of primordial- black-hole clusters

*Wednesday, 4 March 2026 14:00 (20 minutes)*

Primordial black holes (PBHs) are a major candidate for dark matter, expected to form from the collapse of large density fluctuations generated during inflation. Their abundance is highly sensitive to non-linear effects, some of which can be described through the  $\delta N$  formalism. This approach models the universe as a set of locally homogeneous patches evolving independently throughout inflation. However, accounting for the spatial correlations between these patches is crucial to predicting the spatial distribution of PBHs and the formation of clusters. In this talk, after reviewing the  $\delta N$  formalism, I will show how to include spatial correlations within this framework. As an illustration, I will discuss the ultra-slow-roll model and compute the curvature perturbation  $\zeta$  —necessary to determine PBH formation— and its spatial correlations. In the future, this could enable the prediction of PBH binaries and clusters, which may leave observable imprints such as gravitational waves.

**Primary author:** ARTIGAS, Danilo**Presenter:** ARTIGAS, Danilo**Session Classification:** Session II

Contribution ID: 14

Type: **not specified**

## Parity-violating scalar trispectrum from helical primordial magnetic fields

*Wednesday, 4 March 2026 14:20 (20 minutes)*

Observational evidence for cosmic magnetic fields has been accumulated over a wide range of scales, from galaxies and galaxy clusters to cosmic voids, yet their origin remains unsettled. In particular, magnetic fields in voids are difficult to account for solely by astrophysical mechanisms associated with structure formation, making primordial magnetic fields (PMFs) generated in the early universe a compelling candidate. In recent years, helical PMFs—realizable in magnetogenesis scenarios involving parity-violating couplings—have attracted considerable attention. Since magnetic helicity is a conserved quantity, helical fields can undergo an inverse cascade that increases their correlation length, potentially providing an origin for the large-scale magnetic fields observed today. Moreover, current observations have suggested that intergalactic magnetic fields may possess nonzero helicity, making helical PMFs a key target not only for elucidating cosmic magnetism but also for testing cosmological parity violation. In this talk, we focus on curvature perturbations sourced by the PMF anisotropic stress on superhorizon scales, the so-called passive mode. We derive an analytic expression for the trispectrum—the Fourier transform of the four-point correlation function—of the passive scalar mode, including parity-violating contributions sourced by primordial magnetic helicity. Assuming nearly scale-invariant PMF spectra, we evaluate the trispectrum analytically using the pole approximation, which isolates the dominant contributions from modes with wavenumbers near zero. By comparison with direct numerical integrations, we demonstrate that the pole approximation reproduces the qualitative behavior of the exact trispectrum. We then investigate the dependence of the trispectrum amplitude on the Fourier-space configuration by varying both the shape of the wavenumber tetrahedron and the ratio of the helical to non-helical components. Finally, we present an order-of-magnitude estimate of this ratio by relating our results to existing observational constraints on the CMB trispectrum. These results demonstrate that parity-violating signatures originating from primordial magnetic helicity can be imprinted on the cosmic microwave background (CMB) and large-scale structure (LSS) through higher-order correlation functions. Our findings highlight trispectrum-based analyses as a complementary avenue to conventional power-spectrum constraints for probing primordial magnetism.

**Primary author:** KAITO, Yura**Presenter:** KAITO, Yura**Session Classification:** Session II

Contribution ID: 15

Type: **not specified**

## Phenomenological and Gravitational Properties of a Monopole-Domain Wall System

*Wednesday, 4 March 2026 14:40 (20 minutes)*

We consider an exotic object that may be attained in cosmology models permitting the existence of two interacting defects: the magnetical monopole and an axion domain wall. The system is subject to the Witten effect, which gives rise to unique electromagnetic properties. A stable, gravitating solution of the system is formulated; we discuss its relations to the study of other compact objects, and the physical consequences of stable remnants from early universe dynamics.

**Primary author:** KOMIYA, Yu

**Presenter:** KOMIYA, Yu

**Session Classification:** Session II

Contribution ID: 16

Type: **not specified**

## Causality and Kramers-Kronig Relations in Gravitational Lensing

*Wednesday, 4 March 2026 15:30 (1 hour)*

In gravitational-wave lensing, wave-optical effects become significant when the wavelength is comparable to the lens's characteristic scale. I show causality imposes fundamental constraints on the lensed waveform that go beyond geometric optics and transform it to the Kramers-Kronig relations. I will also discuss application of the KK relations to validating lensed GW candidates in a model-independent manner.

**Primary author:** SUYAMA, Teruaki

**Presenter:** SUYAMA, Teruaki

**Session Classification:** Session III

Contribution ID: 17

Type: **not specified**

# Toward estimating supermassive Black Hole Binary Distributions via Higher- Order Statistics of the Gravitational Wave Background

*Wednesday, 4 March 2026 16:30 (20 minutes)*

Recent progress in gravitational wave observations has been significant. Pulsar Timing Arrays (PTAs) aims to detect the Gravitational Wave Background (GWB) formed by sources that cannot be individually resolved in the nanohertz band. The sources of the GWB are considered to be orbital motions of Supermassive Black Hole Binaries (SMBHBs). Extracting physical information, such as the mass and redshift of SMBHBs, from GWB observations is crucial for understanding galaxy evolution and the formation processes of supermassive black holes. However, the observed GWB is significantly stronger than predictions from existing theoretical models. The statistics of the GWB energy density spectrum have been studied previously. While it was shown that statistics (mean, variance, skewness, kurtosis) follow a power law with frequency, the variance and higher-order statistics were known to diverge. This divergence was caused by setting the lower limit of the redshift integration to  $z=0$ . In this study, we devised a method to avoid this divergence by setting the integration lower limit based on the detector sensitivity for individual sources. We analytically derive that these higher-order statistics can be expressed as weighted averages of SMBHB physical parameters, such as mass and redshift. This framework enables the extraction of SMBHB distribution information directly from GWB observations, without relying on population synthesis simulations such as merger tree models. As a first application, we demonstrate that the SMBHB mass distribution can be recovered with reasonable accuracy by solving the inverse problem using our analytical expressions.

**Primary author:** HISAMATSU, Hinano

**Presenter:** HISAMATSU, Hinano

**Session Classification:** Session III

Contribution ID: 18

Type: **not specified**

## Resolving individual signals in the presence of stochastic background in future pulsar timing arrays

*Wednesday, 4 March 2026 16:50 (20 minutes)*

Recent pulsar timing array (PTA) observations have reported evidence for a gravitational wave background (GWB). If this signal is primarily produced by supermassive black hole binaries (SMBHBs), future PTA observations with the Square Kilometre Array (SKA) are expected to detect multiple continuous gravitational waves (CGWs) from bright individual sources in addition to a stochastic GWB. In this study, we revisit the Fe-statistic, a detection method for single source signals in PTA datasets, and introduce an improved model that treats unresolved gravitational waves as a stochastic GWB. We apply this method to mock datasets containing both CGWs and a GWB and evaluate its performance in recovering CGW parameters. We find that the improved Fe-statistic significantly enhances the estimation of the CGW sky location and amplitude, particularly when the GWB dominates over white noise. We further demonstrate that, when combined with MultiNest, the Fe-statistic enables an efficient Bayesian search for CGWs and the GWB simultaneously. This work serves as an initial step toward developing an efficient and robust algorithm for future PTA observations.

**Primary author:** FURUSAWA, Kazuya

**Presenter:** FURUSAWA, Kazuya

**Session Classification:** Session III

Contribution ID: 19

Type: **not specified**

## Testing the standard structure growth with HSC-Y3 cosmic shear data and CMB data: Implications for $S_8$ tension

*Wednesday, 4 March 2026 17:10 (20 minutes)*

I will present the joint analyses of Subaru HSC Year 3 (HSC-Y3) cosmic shear 2-point correlation functions (2PCFs), the Planck CMB data, and the ACT DR6 CMB lensing data, that provide insights into history of the structure growth. In Terasawa et al. 2025d, we considered phenomenological modified gravity models in which the suppression of structure growth is triggered at lower redshifts, as dark energy begins to dominate the background expansion. We show that the modified growth factor models, especially those featuring more rapid growth suppression at lower redshifts, provide an improved fit to the combined datasets compared to the fiducial  $\Lambda$ CDM model. Recent full calibration of the tomographic redshift distribution of the HSC-Y3 Shape Catalog with DESI (Choppin de Janvry et al. 2025a) yields smaller shifts of the mean redshift for the third and fourth redshift bins compared to the official HSC-Y3 self-calibration with the cosmic shear 2PCFs amplitudes. I will also present our interpretation with the growth suppression found in Terasawa et al. 2025d.

**Primary author:** TERASAWA, Ryo

**Presenter:** TERASAWA, Ryo

**Session Classification:** Session III

Contribution ID: 20

Type: **not specified**

## **Intrinsic galaxy alignment cosmology**

*Thursday, 5 March 2026 09:10 (1 hour)*

**Primary author:** OKUMURA, Teppei

**Presenter:** OKUMURA, Teppei

**Session Classification:** Session I

Contribution ID: 21

Type: **not specified**

## Probing Light Dark Matter with Cosmic Gravitational Focusing

*Thursday, 5 March 2026 10:10 (20 minutes)*

We investigate the possibility of using the cosmic gravitational focusing (CGF) to probe the minor light dark matter (DM) component whose mass is in the range of  $(0.1 \sim 100)\text{eV}$ . Being a purely gravitational effect, the CGF offers a mode-independent probe that is complementary to the existing ways such as Lyman- $\alpha$  and  $\Delta N_{\text{eff}}$ . Such effect finally leads to a dipole density distribution that would affect the galaxy formation and hence can be reconstructed with galaxy surveys such as DESI. Both the free-streaming and clustering limits have been studied with analytical formulas while the region in between is bridged with interpolation. We show the projected sensitivity at DESI with the typical phase space distribution of a freeze-in DM scenario as illustration.

**Primary author:** TAN, Liang

**Presenter:** TAN, Liang

**Session Classification:** Session I

Contribution ID: 22

Type: **not specified**

## Constrain the Dark Matter physics through weak lensing observation

*Thursday, 5 March 2026 10:30 (20 minutes)*

Dark matter non-gravitational interactions can modify the evolution of cosmological perturbations in the early Universe, leaving observable imprints on large-scale structure. In this talk, I will introduce several studies that use weak-lensing measurements of the matter distribution—probing scales around  $k \sim 1h/\text{Mpc}$ —to constrain dark matter interactions.

**Primary author:** ZU, Lei

**Presenter:** ZU, Lei

**Session Classification:** Session I

Contribution ID: 23

Type: **not specified**

# Exponential Quintessence Model: Analytical Quantification of the Fine-Tuning Problem in dark energy

*Thursday, 5 March 2026 10:50 (20 minutes)*

We explain the data of the DESI galaxy survey by using theoretical models of time-varying dark energy. Among such models, a quintessence field with the exponential potential is an attractive candidate for inducing time-varying dark energy. We analytically derive constraints on initial conditions that allow the kination epoch in the early Universe without conflicting with big bang nucleosynthesis. Compared to the severe 120-digit fine-tuning required for dark energy to be a cosmological constant, our result shows that the degree of fine-tuning is naturally relaxed by dozens of orders of magnitude. Furthermore, we discuss the method for testing this model through future observations of the gravitational wave background.

**Primary author:** MAKI, Naoto

**Presenter:** MAKI, Naoto

**Session Classification:** Session I

Contribution ID: 24

Type: **not specified**

# Primordial Neutrino Asymmetry: From Theory to Observations

*Thursday, 5 March 2026 12:45 (1 hour)*

**Primary author:** KASAI, Kentaro

**Presenter:** KASAI, Kentaro

**Session Classification:** Session II

Contribution ID: 25

Type: **not specified**

**TBA**

*Thursday, 5 March 2026 13:45 (1 hour)*

**Primary author:** NITTA, Tatsumi

**Presenter:** NITTA, Tatsumi

**Session Classification:** Session II

Contribution ID: 26

Type: **not specified**

## Gravitational waves from coalescing supermassive black holes in a galaxy and AGN formation model based on the CDM cosmology

*Thursday, 5 March 2026 15:00 (1 hour)*

I discuss how to make predictions for the amplitude of the gravitational-wave background (GWB) produced by supermassive black hole (SMBH) binaries and for the event rate of SMBH coalescences within the framework of galaxy formation theory in a cold dark matter (CDM) universe. The former can be detected by pulsar timing arrays (PTAs), while the latter will be probed by LISA. We have developed a semi-analytic model of galaxy and active galactic nucleus (AGN) formation that successfully reproduces the observed luminosity functions of galaxies and AGN, as well as the empirical relations between bulge mass and black hole mass. This agreement implies that the SMBH binary merger rates in our model are tightly constrained by observations in both the local and high-redshift universe. Our current model predicts a lower GWB amplitude than that reported by the NANOGrav collaboration, and I discuss the implications of this discrepancy.

**Primary author:** NAGASHIMA, Masahiro

**Presenter:** NAGASHIMA, Masahiro

**Session Classification:** Session III & Closing