Focus Workshop on Cosmological Phase Transitions: Theory, Dark Matter Genesis, and Gravitational Wave Signatures

Report of Contributions

https://indico.ibs.re.kr/e/972

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

Probing CP violation for electroweak baryogenesis in 2HDM

Thursday, 20 November 2025 14:00 (1 hour)

In this talk, we discuss CP violation and electroweak baryogenesis in 2HDM.
We consider a scenario where the top quarks generate the baryon asymmetry, but the light-fermion couplings are suppressed to avoid strong constraints from EDM measurements.
In our scenario, it is found that the leading contributions arise in the top-quark EDMs at the two-loop level, which induce the electron, neutron, and proton EDMs.
We show that our scenario is compatible with the current experimental bounds and is within the scope of future EDM experiments.
We also discuss the other probe of the CP violation in the 2HDM, the H±W±Z vertices, which would be important to know the symmetry structure of the Higgs potential in the future.

Presenter: MURA, Yushi

Session Classification: Session 2

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

Discussion

Thursday, 20 November 2025 15:00 (30 minutes)

Session Classification: Session 2

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

An Invitation to the Hamiltonian Formulation of Lattice Gauge Theories

Thursday, 20 November 2025 16:00 (1 hour)

Nonperturbative first-principles calculations are central to studies of cosmological phase transitions, including the hot electroweak and QCD phase diagrams. Euclidean path-integral Monte Carlo has yielded reliable results for thermal transitions. However, real-time dynamics, the QCD phase diagram at finite baryon density, and θ terms suffer from the sign problem. The Hamiltonian formulation of lattice gauge theories provides a complementary approach. In this talk, I will review the Hamiltonian approach to lattice gauge theories, outline its basic structure and numerical methods, and present recent results for two-color QCD at finite density within this framework.

Presenter: FUJIKURA, Kohei

Session Classification: Session 3

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

Discussion

Thursday, 20 November 2025 17:00 (30 minutes)

Session Classification: Session 3

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

Extended Higgs sectors and EW baryogenesis

Friday, 21 November 2025 10:30 (1 hour)

We discuss various phenomenological aspects of physics in the model for EW baryogenesis based on the extended Higgs sectors. Important discriminative predictions of the scenario of EW baryogenesis are the phenomena from extra CP violation and the first order EW phase transition. We discuss some phenomenological features of models of EW baryogenesis and how to test such models by future experiments. If time allows, we may also be able to discuss a model which can simultaneously explain neutrino mass, dark matter and baryogenesis by the physics at the TeV scale.

Presenter: KANEMURA, Shinya (University of Toyama)

Session Classification: Session 4

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

Discussion

Friday, 21 November 2025 11:30 (30 minutes)

Session Classification: Session 4

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

MeV First-Order Dark Phase Transitions

Friday, 21 November 2025 14:00 (1 hour)

MeV-scale first-order phase transitions (FOPT) can generate stochastic gravitational waves (GW) in
the nanohertz frequency, which can now be probed by Pulsar Timing Array experiments and will be targeted by
Square Kilometer Array. Nanohertz GW can also give rise to spectral distortions in the cosmic microwave
background and modification of the effective number of neutrino species, providing complementary probes in
cosmology. In addition, MeV-scale FOPT can also leave some strong consequences at colliders. This talk is
devoted to these complementary probes in cosmology and colliders, and bringing the challenges of dark
matter production in the minimal setup.

Presenter: LI, Shaoping

Session Classification: Session 5

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

Discussion

Friday, 21 November 2025 15:00 (30 minutes)

Session Classification: Session 5

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

TBA

Friday, 21 November 2025 16:00 (1 hour)

Presenter: KEUS, Venus (Dublin Institute for Advanced Studies (DIAS))

Session Classification: Session 6

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

Discussion

Friday, 21 November 2025 17:00 (30 minutes)

Session Classification: Session 6

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

Thermal nucleation: bridging simulations and analytics

Saturday, 22 November 2025 10:00 (1 hour)

TBA

Presenter: HIRVONEN, Joonas (University of Nottingham)

Session Classification: Session 7

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

Discussion

Saturday, 22 November 2025 11:00 (30 minutes)

Session Classification: Session 7

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

Primordial Black Hole catalyzes the First-Order Electroweak Phase Transition and its Parameter Space

Saturday, 22 November 2025 11:30 (1 hour)

We discuss the catalysis of the primordial black holes(PBH) on the first-order electroweak phase transition(FOEWPT). We accurately studied the nucleation rate for bubbles around the PBH by solving the Einstein and bounce equations rather than applying the thin-wall approximation. We found the ordinary thin-wall approximation will overestimate the nucleation rate. For the first time, we showed how the PBH altered the parameters space of new physics. We use the concrete model: the triplet extension of the standard model(ΣSM) to demonstrate this effect and found the PBH with suitable mass $M_{PBH} < 10^{11}g$ will nearly double the viable parameter space for the two-step FOEWPT in ΣSM. Those PBHs will also induce a supercooling FOEWPT in the new extended parameter regions and generate an observable stochastic gravitational wave signal without changing the observational signal for ordinary parameters space.

Presenter: ZHU, Jiang (Shanghai jiao tong univercity)

Session Classification: Session 8

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

Discussion

Saturday, 22 November 2025 12:30 (30 minutes)

Session Classification: Session 8

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

Statistical Analysis of FOPT over an Extended Bandwidth as a Probe of New Physics

Saturday, 22 November 2025 14:30 (1 hour)

Collider-based searches for new physics are inherently limited in both energy reach and experimental precision. In contrast, first-order phase transitions (FOPTs) in the early universe can probe much higher fundamental scales, making it valuable to place observational constraints on a broad class of models. We propose a combined statistical analysis across multiple frequency bands that can set limits on FOPT signals at specific energy scales and serve as a general framework for constraining couplings and masses in a wide range of theories. In this talk, I present a concrete example using real LIGO data to derive constraints on a generic U(1) model.

Presenter: VELASCO SEVILLA, Liliana (Sogang University)

Session Classification: Session 9

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

Discussion

Saturday, 22 November 2025 15:30 (30 minutes)

Session Classification: Session 9

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

Nonthermal heavy dark matter from a first-order phase transition

Saturday, 22 November 2025 16:30 (1 hour)

We study nonthermal production of heavy dark matter from the dynamics of the background scalar field during a first-order phase transition, predominantly from bubble collisions. In scenarios where bubble walls achieve runaway behavior and get boosted to very high energies, we find that it is possible to produce dark matter with mass several orders of magnitude above the symmetry breaking scale or the highest temperature ever reached by the thermal plasma. We also demonstrate that the existing formalism for calculating particle production from bubble dynamics in a first-order phase transition is not gauge invariant, and can lead to spurious results. Thus, we provide a practical prescription for the computation that avoids unphysical contributions and should provide reliable order-of-magnitude estimates of this effect. Furthermore, we point out the importance of three-body decays of the background field excitations into scalars and gauge bosons, which provide the dominant contributions at energy scales above the scale of symmetry breaking. Using our improved results, we find that scalar, fermion, and vector dark matter are all viable across a large range of mass scales, from O(10) TeV to a few orders of magnitude below the Planck scale, and the corresponding phase transitions can be probed with current and future gravitational wave experiments.

Presenter: LEE, Hyun Min (Chung-Ang University)

Session Classification: Session 10

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

Discussion

Saturday, 22 November 2025 17:30 (30 minutes)

Session Classification: Session 10

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

TBA

Sunday, 23 November 2025 10:00 (1 hour)

Presenter: JINNO, Ryusuke

Session Classification: Session 11

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

Discussion

Sunday, 23 November 2025 11:00 (30 minutes)

Session Classification: Session 11

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

Gravitational Wave Signals from Dark Higgs Inflation and Grand Unification

Sunday, 23 November 2025 11:30 (1 hour)

I will discuss the production of gravitational waves from a first-order phase transition in a "Dark Higgs Inflation" model (providing a unified framework for inflation and observable gravitational waves from a phase transition) and in an SO(10) Grand Unified Theory.

Presenter: KERSTEN, Joern (Yonsei University)

Session Classification: Session 12

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

Discussion

Sunday, 23 November 2025 12:30 (30 minutes)

Session Classification: Session 12

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

Consistent Thermal Resummation and Phase Transitions with 2PI Methods

Thursday, 20 November 2025 10:30 (1 hour)

The scalar potential at finite temperature is often used to track the thermal evolution of the universe and in the study of cosmological phase transitions (PTs). As observables, such as the spectrum of gravitational waves (GWs), can ultimately be derived from this quantity, it must be computed accurately. We first review the calculation of the finite-temperature effective potential, emphasizing the need for resummation to address infrared divergences at finite temperature. After an overview of the resummation schemes commonly used in phenomenological studies, we clarify their regimes of validity. We then employ the two-particle irreducible (2PI) formalism as a framework for consistent thermal resummation, demonstrating its treatment of high- and low-temperature corrections on an equal footing. Considering a toy model with two scalar fields, we compute the PT parameters (the temperature, duration, and strength of the transition), and compare the results obtained across resummation schemes. Finally, we use these PT parameters to evaluate the resulting GW spectra, demonstrating how the choice of resummation scheme can significantly affect the predicted signal.

Presenter: BANIK, Amitayus (Chungbuk National University)

Session Classification: Session 1

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

Discussion

Thursday, 20 November 2025 11:30 (30 minutes)

Session Classification: Session 1