Strong and Electroweak Matter 2016

Report of Contributions

https://indico.cern.ch/e/sewm2016

Contribution ID: **1** Type: **Talk**

Equation of state of QCD from analytical continuation

Wednesday, 13 July 2016 15:15 (30 minutes)

We determine the 2+1 flavour equation of state of QCD at finite chemical potential to order $(\mu_B/T)^6$ from lattice simulations. The simulations are performed at
the physical mass for the light and strange quarks on several lattice spacings;
the results are continuum extrapolated. The coefficients of the expansion in
(μ_B/T) are determined through the analytic continuation from imaginary chemical potentials of the baryonic density. Strangeness neutrality and charge conservation are imposed, to match the experimental conditions at heavy ion colliders. The pressure and interaction measure are calculated along the isentropic trajectories in the (T, μ_B)
plane corresponding to the RHIC Beam Energy Scan collision energies.

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Co-authors: RATTI, Claudia (University of Houston); GÜNTHER, Jana (University of Wuppertal); SZABO, Kalman (Forschungszentrum Julich); BELLWIED, Rene (University of Houston (US)); KATZ, Sandor (Eotvos University); BORSANYI, Szabolcs (University of Wuppertal); FODOR, Zoltan (BUW)

Presenter: PASZTOR, Attila (Wuppertal University)

Session Classification: Parallel Track 1

Contribution ID: **2** Type: **Talk**

Next-to-leading order nPI calculations in scalar theories

Tuesday, 12 July 2016 15:00 (30 minutes)

Previous calculations have shown that the 2 particle irreducible (2pi) effective theory is a promising method to study strongly coupled systems, for which non-perturbative techniques are needed. Calculations at the 3 loop level show improved convergence, relative to perturbative results. We present results in \phi^4 theory at the 4 loop level which show that convergence breaks down at large coupling. This indicates the need for higher order effective theories.
4pi calculations in 4 dimensions have never been attempted, because no method is known to deal with the overlapping sub-divergences that appear in these theories. We present a new technique to renormalize the 4pi effective theory, based on a renormalization group approach.

Primary author: CARRINGTON, Margaret (Brandon University)

Presenter: CARRINGTON, Margaret (Brandon University)

Session Classification: Parallel Track 3

Contribution ID: **3** Type: **Talk**

The effects of higher order truncations in the 2PI description of phase transitions

Tuesday, 12 July 2016 13:30 (30 minutes)

We thoroughly investigated the applicability of the two-particle irreducible
(2PI) formalism in the description of phase transitions occurring at finite temperature in scalar field theories. We studied the importance of truncation effects on the order of the phase transition and indeed found that the long known problem of the Hartree-Fock truncation is cured by improving the approximation to the next level. during the investigation of Bose-Einstein condensation at finite density we found infrared problems one might face in the self-consistent treatment of the propagators. We studied this problem in more detail developing various semi-analytical localized approximations. We have shown within a truncation at two-loop level that the so-called symmetry improved 2PI, recently proposed in the literature to enforce the Goldstone theorem on the variational propagator, results in a loss of solution to the self-consistent propagator equations because the resummation cannot cope with the deep IR modes. We think that the most likely way out for this rather general problem is to employ vertex resummations e.g. using 1/N expansion to next to leading order in the 2PI effective action.

Primary authors: MARKO, Gergely (MTA-ELTE Statistical and Biological Physics Research Group); Dr REINOSA, Urko (CPHT, Ecole polytechnique, CNRS); Dr SZEP, Zsolt (MTA-ELTE Statistical and Biological Physics Research Group)

Presenter: MARKO, Gergely (MTA-ELTE Statistical and Biological Physics Research Group)

Session Classification: Parallel Track 3

Contribution ID: **4** Type: **Talk**

Real-time dynamics of the Chiral Magnetic Effect

Thursday, 14 July 2016 16:00 (30 minutes)

We present a first-principles study of the dynamics of the Chiral Magnetic Effect based on real-time lattice gauge theory simulations with dynamical fermions. We demonstrate how topological densities and transitions during the early stages of high-energy collision lead to the production of axial charge imbalances via the the axial anomaly and investigate in detail the interplay between axial and vector currents in the presence of strong magnetic fields. We also discuss how such simulations can be utilized to provide initial conditions for the evolution in anomalous hydrodynamics, to improve the understanding of experimental signatures of the effects in high-energy heavy-ion collisions.

Primary authors: BERGES, Jürgen (Heidelberg University); TANJI, Naoto (Heidelberg University); MUELLER, Niklas (Heidelberg University); SHARMA, Sayantan (BNL); SCHLICHTING, Soeren (Brookhaven National Lab)

Presenter: MUELLER, Niklas (Heidelberg University)

Session Classification: Parallel Track 2

Contribution ID: **5** Type: **Talk**

Far-from-equilibrium universality classes: From heavy-ion collisions to superfluid scalar systems

Thursday, 14 July 2016 16:30 (30 minutes)

Quantum many-body systems far from equilibrium can approach a nonthermal fixed point during their real-time evolution. One example is scalar field theory, which occurs in models of cosmological inflation, and similar examples are found for ultracold Bose gases and for non-Abelian plasmas relevant for heavy-ion collisions. We present two novel far-from-equilibrium universality classes that provide links between these field theories.
One of them involves nonrelativistic, relativistic and expanding scalar systems. It occurs in the deep infrared regime of very high occupancies and leads to the formation of a Bose-Einstein condensate. The other novel universality class encompasses scalar field theories and non-Abelian plasmas in a longitudinally expanding background and corresponds to an early dynamical stage of heavy-ion collisions in the high-energy limit.
The observed universality connects different physics disciplines from heavy-ion collisions to ultracold atoms, making a remarkable link between the world's hottest and coldest matter.

Primary author: BOGUSLAVSKI, Kirill (University of Heidelberg)

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Presenter: BOGUSLAVSKI, Kirill (University of Heidelberg)

Session Classification: Parallel Track 2

Contribution ID: **6** Type: **Talk**

Chiral symmetry restoration from the hadronic regime

Thursday, 14 July 2016 14:00 (30 minutes)

We will present recent results regarding chiral symmetry restoration and other hadronic properties at finite temperature. In particular, we will discuss the interpretation of the temperature dependence of lattice screening masses through Ward identities relating pseudoscalar susceptibilities and quark condensates. Such identities are derived for two and three flavours and studied within the $SU(2)$, $SU(3)$ and $U(3)$ frameworks of Chiral Perturbation Theory, including axial anomaly and η' corrections. We will also examine chiral degeneration patterns and the role of the $f_0(500)$ or σ state in the saturation of the scalar susceptibility, where our results are consistent with lattice data. The $f_0(500)$ thermal state is generated dynamically from pion scattering and thermal unitarity, both within unitarized ChPT and in other schemes such as that with large number of Goldstone Bosons. Aspects regarding external magnetic fields could also be discussed. Recent references: JHEP 1603 (2016) 186, Phys.Rev. D93 (2016) no.3, 036001.

Primary author: GOMEZ NICOLA, Angel (Universidad Complutense Madrid)

Co-authors: Dr RUIZ DE ELVIRA, Jacobo (HISKP University Bonn); Prof. MORALES, John (Universidad Nacional de Colombia); CORTES, Santiago (Universidad de los Andes)

Presenter: GOMEZ NICOLA, Angel (Universidad Complutense Madrid)

Session Classification: Parallel Track 3

Contribution ID: **7** Type: **Talk**

Effective field theory techniques applied to the hard scales of the plasmas

Wednesday, 13 July 2016 09:00 (45 minutes)

We show that effective field theory techniques can be applied
in the high temperature T plasmas to
improve the accuracy of the physics of the hard scales (or scales of order T).
At leading order in the
coupling constant the hard scales of the plasma can be viewed as
on-shell classical particles. Based on this observation, and without any
reference
to the state of the system, we derive an effective field
theory describing the quantum fluctuations around an on-shell fermion with
energy p, described as a set of high dimension operators over the on-shell energy
p. When applied to systems close to equilibrium, when for most on-shell particles p ˜ T,
we show that the
on-shell effective field theory (OSEFT) properly describes the HTL photon
polarization tensor of QED, and its 1/T corrections. We also show how with
the OSEFT one can derive quantum corrections
to classical transport equations.

Primary author: MANUEL, Cristina (CSIC-IEEC)

Co-authors: SOTO, Joan; Dr STETINA, Stephan (INT, U. Washington)

Presenter: MANUEL, Cristina (CSIC-IEEC)

Session Classification: Plenary

Contribution ID: **8** Type: **Talk**

Gravitational waves from the phase transition of a nonlinearly realised electroweak symmetry

Thursday, 14 July 2016 16:30 (30 minutes)

The 125 GeV Higgs may be a singlet under a nonlinearly realised electroweak symmetry. Differing from the SM, anomalous Higgs cubic couplings are then permitted in the potential, which may lead to a first order electroweak phase transition. We find a range of cubic coupling that may lead to observable gravitational waves signatures at interferometer such as eLISA.

Primary authors: MANNING, Adrian (The University of Sydney); KOBAKHIDZE, Archil (The University of Sydney); YUE, Jason Tsz Shing (University of Sydney)

Presenter: YUE, Jason Tsz Shing (University of Sydney)

Session Classification: Parallel Track 1

Contribution ID: **9** Type: **Talk**

Leptogenesis and gravity: baryon asymmetry without decays

Wednesday, 13 July 2016 14:45 (30 minutes)

Explaining the matter-antimatter asymmetry of the Universe remains one of the most intriguing problems in particle physics and cosmology. A popular class of theories attributes this asymmetry to CP-violating decays of super-heavy particles in the Early Universe. We present a new source of baryogenesis within these models, and show how the same Yukawa phases which provide the CP-violation for decays, combined with curved-spacetime loop effects, allow matter and antimatter to fall differently in the presence of gravity. This splits the energy spectrum for matter and antimatter, driving the system towards an asymmetric state. By analysing the full Boltzmann equation, we demonstrate regions of parameter space where the observed asymmetry is produced solely by gravitational effects, with decays playing no part at all.

Primary author: Mr MCDONALD, Jamie (Swansea University)

Co-author: SHORE, Graham Martin (Swansea University (GB))

Presenter: Mr MCDONALD, Jamie (Swansea University)

Session Classification: Parallel Track 3

Contribution ID: **10** Type: **Talk**

Thermal contributions to the soft dijet function

Tuesday, 12 July 2016 15:00 (30 minutes)

We present the first analysis of event shape distributions in e+e- annihilation into a dijet pair in a high-temperature quark-gluon plasma in thermal equilibrium. We focus on temperatures much smaller than the jet mass, such that the jet function remains unresolved by medium fluctuations. In this limit, the medium influences the cross-section of the process only through the dijet soft function that describes the inter-jet activity and is a central ingredient for several event shape observables, such as thrust and jet mass distributions. Concretely, we calculate moments of the soft function by extracting the expectation values of energy flow operators, that are in turn closely related to energy-energy correlations. We demonstrate that, at next-to-leading (gˆ2) order, the thermal contribution to the moments of the hemisphere mass distribution factorise, which allows us to resum all moments and thus reconstruct the full soft function. Finally, we comment on higher-order (gˆ4) corrections and the relevance of event shape observables in the context of the ongoing ultrarelativistic heavy-ion experiments.

Primary author: TYWONIUK, Konrad (CERN)

Co-author: CASALDERREY SOLANA, Jorge (University of Barcelona (ES))

Presenter: TYWONIUK, Konrad (CERN)

Session Classification: Parallel Track 1

Contribution ID: **11** Type: **Talk**

Axial charge dynamics: topological transition and quark mass effect

The dynamics of axial charge has been a key component of the celebrated chiral magneic effect (CME) and chiral magnetic wave (CMW) in heavy ion collisions. Due to the non-conservation of axial charge, the inclusion of axial charge in hydrodynamic equations is a subtle issue. On one hand, axial charge is generated by fluctuation owing to its non-conservation, on the other hand, the non-conservation also provide mechanism of charge dissipation. A more appropriate treatment is to use stochastic hydrodynamics for axial charge. In this talk, I will discuss two sources of non-conservation: topological transition[1,2] and quark mass[3]. Both of them contribute to the fluctuation and dissipation of axial charge.

[1] I. Iatrakis, S. Lin and Y. Yin, "Axial current generation by P-odd domains in QCD matter" Phys. Rev. Lett.114 (2015)
[2] I. Iatrakis, S. Lin and Y. Yin, "The anomalous transport of axial charge: topological vs non-topological fluctuations", JHEP 030 (2015)
[3] E-d. Guo and S. Lin, "Quark mass effect on axial charge dynamics", Phys. Rev. D 93 (2016)

Primary author: LIN, Shu (Sun Yat-Sen University)

Co-authors: GUO, Er-dong (ITP, CAS); IATRAKIS, Ioannis (Utrecht University); YIN, Yi (Brookhaven national laboratory)

Presenter: LIN, Shu (Sun Yat-Sen University)

Session Classification: Parallel Track 3

Contribution ID: **12** Type: **Talk**

Quark matter and neutron stars

Thursday, 14 July 2016 17:00 (30 minutes)

We will describe recent progress in perturbative and holographic calculations of the bulk thermodynamic properties of dense quark matter, both at zero and finite temperatures. Particular attention will be placed on the Equation of State and the question, how information about the behavior of this quantity at high densities can be combined with low-density results to constrain the observable properties of neutron stars.

Primary author: VUORINEN, Aleksi

Presenter: VUORINEN, Aleksi

Session Classification: Parallel Track 3

Contribution ID: **13** Type: **Talk**

Confinement and Chiral Symmetry Breaking from an ensemble of interacting Instanton-dyons(monopoles) in SU(2) QCD

Thursday, 14 July 2016 15:00 (30 minutes)

We show how the increase in the Instanton-dyon density can explain both Confinement and Chiral symmetry breaking. We simulate an ensemble of 64 interacting Instanton-dyons for 2 colors and 0 or 2 quark flavors. We find that at low temperatures, the high density of dyons prefer a symmetric density, which leads to the confining value of the Polyakov Loop. At the same time the Chiral condensate is highly sensitive to the Polyakov Loop. As the Polyakov Loop gets close to the confining value, the Chiral condensate develops a non-zero expectation value, thus breaking Chiral symmetry.

Primary author: LARSEN, Rasmus (Stony Brook University)

Co-author: SHURYAK, Edward (stony brook university)

Presenter: LARSEN, Rasmus (Stony Brook University)

Session Classification: Parallel Track 1

Contribution ID: **14** Type: **Talk**

Thermal Gravitino Production due to Bremsstrahlung and Annihilation Processes

Thursday, 14 July 2016 14:30 (30 minutes)

In a theory in which (local) supersymmetry is spontaneously broken for temperatures T \ll M_{pl}, where M_{pl} is the Planck mass, gravitinos couple to MSSM particles via the supercurrent. Thermal gravitino production rate per unit volume due to the strongly interacting sector of the theory can be calculated perturbatively, and to leading order in the QCD coupling \alpha_s(T), is of order \alpha_s(T) (\frac{T}{M_{pl}})^2 T^4. The contribution from 2->2 scatterings of plasma particles with each other has already been calculated. There are, however, additional processes that contribute at the same order which have been overlooked in the literature: bremsstrahlung of gravitinos by quarks, squarks, gluons and gluinos in the thermal bath, and annihilation of these particles to gravitinos. A consistent treatment of these N+1 \rightarrow N+2 processes requires that Landau-Pomeranchuk-Migdal effect be incorporated in the calculation.

Primary author: Prof. DOĞAN, Çağlar (Istanbul University)

Presenter: Prof. DOĞAN, Çağlar (Istanbul University)

Session Classification: Parallel Track 1

Contribution ID: **15** Type: **Talk**

Quantum inferference in showering: LPM effect for sequential bremsstrahlung

Wednesday, 13 July 2016 13:45 (30 minutes)

High-energy particles passing through matter lose energy by showering via hard bremsstrahlung and pair production. At very high energy, the quantum duration of each splitting process, known as the formation time, exceeds the mean free time for collisions with the medium, leading to a significant reduction in the splitting rate, known as the Landau-Pomeranchuk-Migdal (LPM) effect. In the QCD case, there are important and potentially important corrections to the usual treatment of the LPM effect, arising from cases where the coherence lengths of two consecutive splitting processes overlap. I will discuss the computation of such corrections beyond leading-log approximation.

Primary author: ARNOLD, Peter (University of Virginia)

Presenter: ARNOLD, Peter (University of Virginia)

Session Classification: Parallel Track 2

Contribution ID: **16** Type: **Talk**

Non Perturbative Renormalization Group for scalar fields in de Sitter space

Thursday, 14 July 2016 14:00 (30 minutes)

We address the issue of light scalar fields in de Sitter space using the non perturbative renormalization group. The derivative expansion used in flat space is adapted to this context. At lowest order, the Local Potential Approximation reproduces results of the stochastic approach. We discuss mass and coupling generation as well as radiative symmetry restoration. A simplified first order expansion shows that the flow is slowed down but yields the same IR physics, suggesting that a higher order computation is necessary to capture corrections to the stochastic approach.

Primary author: GUILLEUX, Maxime (Université Paris Diderot)

Presenter: GUILLEUX, Maxime (Université Paris Diderot)

Session Classification: Parallel Track 2

Contribution ID: **17** Type: **Talk**

Thermalization of Schwinger-Keldysh correlation functions in holograpahy

Tuesday, 12 July 2016 15:00 (30 minutes)

Holography provides a powerful tool for studying out-of-equilibrium strongly interacting quantum fields. Most works on this subject have focused on the dynamics of local operators, as for instance on how quickly they approach hydrodynamic behavior. We have developed the first general method for studying time-dependence of the causal response function in holography for arbitrary non-equilibrium states and external quench protocols by vastly improving pre-existing methods. This method has been further extended for obtaining all non-equilibrium Schwinger-Keldysh correlation functions (to appear soon). We will present results on the time-dependence of the spectral function in AdS-Vaidya geometries dual to non-equilibrium states driven by a homogeneous quench of an arbitrary duration. Unlike the one-point functions, the spectral function exhibits four distinct patterns of time-dependence (initial time dynamics and thermalization) characterized by very well-defined features going to be described. It can be readily argued that holography can help us to classify patterns of thermalization of correlation functions in strongly coupled large-N theories based on a few simple combinations of extrinsic and intrinsic parameters, in a manner analogous to how we use the Reynolds number to classify hydrodynamic flows. We will discuss connections with solid-state experiments and heavy-ion physics.

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Presenter: MUKHOPADHYAY, Ayan (Vienna University of Technology)

Session Classification: Parallel Track 2

Contribution ID: **18** Type: **Talk**

Study of the chiral phase transition with vector and axial-vector mesons in an extended linear sigma model within the functional renormalization group approach

Thursday, 14 July 2016 13:30 (30 minutes)

We use the functional renormalization group (FRG) technique to explore the characteristics of the chiral phase transition between the hadronic phase of quantum chromodynamics and the quark-gluon plasma. The restoration of chiral symmetry at high temperatures and/or net-baryon densities leads to changes in the in-medium spectral properties of light vector mesons, directly affecting the dilepton spectrum measurable in heavy-ion collisions. Therefore a study of vector and axial-vector mesons is indispensable for understanding the underlying mechanism of chiral symmetry restoration.

The theoretical framework for our investigation is the so-called extended linear sigma model (eLSM). This model is an effective description of the strong interaction which features besides scalars and pseudoscalars also vector and axial-vector mesons. Here, all degrees of freedom in the eLSM are exclusively treated beyond mean-field, i.e. they are involved in the FRG flow and, consequently, are subject to quantum and statistical fluctuations.

Recent results on the order of the chiral phase transition and on the mass degeneracy of chiral partners occurring beyond the phase boundary are presented. The chiral limit as well as the effect of the axial anomaly are examined. Finally, the inclusion of quark fields will be discussed. This study may serve as the starting point for computing the vector meson spectral functions in the near future.

Primary author: ESER, Jürgen (Goethe-University Frankfurt)

Co-author: RISCHKE, Dirk (University Frankfurt)

Presenter: ESER, Jürgen (Goethe-University Frankfurt)

Session Classification: Parallel Track 3

Contribution ID: **19** Type: **Talk**

Energy Loss in Unstable Quark-Gluon Plasma

Tuesday, 12 July 2016 14:30 (30 minutes)

The momentum distribution of quark-gluon plasma at the early stage of a relativistic heavy-ion collision is anisotropic and consequently the system, which is assumed to be weakly coupled, is unstable due to chromomagnetic plasma modes. We consider a high-energy parton which flies across such an unstable plasma, and the energy transfer between the parton and the medium is studied as an initial value problem. In the case of equilibrium plasmas, the well-known formula of collisional energy loss is reproduced. The unstable plasma case is much more complex, and the parton can lose or gain energy depending on the initial conditions. The extremely prolate and extremely oblate systems are considered as examples of unstable plasmas, and two classes of initial conditions are discussed. When the initial chromodynamic field is uncorrelated with the color state of the parton, it typically looses energy, and the magnitude of the energy loss is comparable to that in an equilibrium plasma of the same density. When the initial chromodynamic field is induced by the parton, it can be either accelerated or decelerated depending on the relative phase factor. With a correlated initial condition, the energy transfer grows exponentially in time and its magnitude can much exceed the absolute value of energy loss in an equilibrium plasma. The energy transfer is also strongly directionally dependent. Consequences of our findings for the phenomenology of jet quenching in relativistic heavy-ion collisions are briefly discussed.

Primary author: MROWCZYNSKI, Stanislaw (Jan Kochanowski University)

Co-authors: DEJA, Katarzyna (National Centre for Nuclear Research); CARRINGTON, Margaret (Brandon University)

Presenter: MROWCZYNSKI, Stanislaw (Jan Kochanowski University)

Session Classification: Parallel Track 1

Contribution ID: **20** Type: **Talk**

Rapid thermal co-annihilation through bound states

Thursday, 14 July 2016 13:30 (30 minutes)

The coannihilation rate of kinetically equilibrated non-relativistic particles plays an essential role in the classic WIMP dark matter scenario. If the dark matter particles interact attractively, for instance through Z0 exchange, the coannihilation rate could be substantially increased with respect to a tree-level estimate, a phenomenon known as the Sommerfeld effect. We study this physics in an analogous QCD situation, replacing WIMPs by charm or bottom quarks at a temperature of a few hundred MeV. Through resummed perturbative estimates and lattice simulations, we demonstrate that the coannihilation rate can increase much more than predicted by the standard Sommerfeld enhancement, by up to two orders of magnitude. The boost originates from the formation of (thermally broadened) bound states, which subsequently decay.

Primary author: LAINE, Mikko (U. Bern)

Presenter: LAINE, Mikko (U. Bern)

Session Classification: Parallel Track 1

Contribution ID: **21** Type: **Talk**

Chiral magnetic effect and chiral kinetic theory

Thursday, 14 July 2016 16:00 (30 minutes)

A power expansion scheme is set up to determine the Wigner function that satisfies the quantum kinetic equation for spin-1/2 charged fermions in a background electromagnetic field. Vector and axial-vector current induced by magnetic field and vorticity are obtained simultaneously from the Wigner function. The chiral magnetic and vortical effect and chiral anomaly are shown as natural consequences of the quantum kinetic equation. The axial-vector current induced by vorticity is argued to lead to a local polarization effect along the vorticity direction in heavy-ion collisions.

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Presenter: Dr PU, Shi (Institute for Theoretical Physics, Goethe University, Frankfurt am Main)

Session Classification: Parallel Track 3

Contribution ID: **22** Type: **Talk**

Event-by-event picture for the medium-induced jet evolution

Tuesday, 12 July 2016 14:00 (30 minutes)

We discuss the evolution of an energetic jet which propagates through a dense quark-gluon plasma and radiates gluons due to its interactions with the medium. Within perturbative QCD, this evolution can be described as a stochastic branching process, that we have managed to solve *exactly*.
We present exact, analytic, results for the gluon spectrum (the average gluon distribution) and for the higher n-point functions, which describe correlations and fluctuations.
Using these results, we construct the event-by-event picture of the gluon distribution produced via medium-induced gluon branching.

In contrast to what happens in a usual QCD cascade in vacuum, the medium-induced branchings are *quasi-democratic*, with offspring gluons carrying sizable fractions of the energy of their parent parton. This results in *wave turbulence* - an efficient mechanism for the transport of energy from the jet towards the medium.
This mechanism is characterized by a power-law (*Kolmogorov*) spectrum and by *large fluctuations* in the energy loss and the multiplicity of soft gluons. The multiplicity distribution is predicted to exhibit *KNO (Koba-Nielsen-Olesen) scaling*. These predictions can be tested in Pb+Pb collisions at the LHC, via event-by-event measurements of the di-jet asymmetry.

Based on e-Print: arXiv:1601.03629 [hep-ph] published in **JHEP 1605 (2016) 008**

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Co-author: Dr ESCOBEDO, Miguel (IPhT Saclay)

Presenter: Dr IANCU, Edmond (IPhT Saclay)

Session Classification: Parallel Track 1

Contribution ID: **23** Type: **Talk**

Gravitational waves as a probe of the electroweak phase transition

Thursday, 14 July 2016 16:00 (30 minutes)

A first-order phase transition produces gravitational waves and such a transition only occurs if there is physics beyond the standard model. In this sense gravitational wave experiments can be considered as detectors of new physics. In this talk we review the status of the eLISA experiment and we analyze its capabilities for probing a first-order phase transition. We demonstrate that in some cases eLISA is able to discover new physics arising at the electroweak scale or even much above. Moreover, by considering some illustrative beyond-the-standard-model scenarios with a first-order electroweak phase transition, we highlight the existence of parameter regions that are hard to probe at the LHC but are testable at eLISA.

Primary author: NARDINI, Germano (DESY)

Presenter: NARDINI, Germano (DESY)

Session Classification: Parallel Track 1

Contribution ID: **24** Type: **Talk**

Monitoring shock wave collisions with non local observables

Tuesday, 12 July 2016 14:00 (30 minutes)

Understanding the complicated field dynamics taking place in a heavy ion collision is a difficult task. Holography provides us with a framework that enables us to study the strongly coupled sector of certain gauge theories.
We mimic the heavy ion collision by two gravitational shock waves and monitor the time evolution of the dual strongly coupled super Yang-Mills plasma via non-local observables such as two-point functions and entaglement entropy.
Different initial conditions exhibit different phenomenology with respect to non-local observables. We show that entanglement entropy can be used as an order parameter to distinguish between the two phases of the cross-over from the transparency to the full-stopping scenario in dynamical Yang-Mills formation.

Primary author: STRICKER, Stefan (TU Wien)

Presenter: STRICKER, Stefan (TU Wien)

Session Classification: Parallel Track 2

Contribution ID: **25** Type: **Talk**

Non-equilibrium dynamics of inhomogeneous quantum fields

Tuesday, 12 July 2016 14:00 (30 minutes)

The dynamics of inhomogeneous quantum fields out of equilibrium are especially relevant for the study of first-order phase transitions. It is our aim to calculate how critical bubbles of the new phase -that form in such a process- propagate for different quantum field theories. The Electroweak phase transition in the early universe is of particular interest, since Baryogenesis can potentially explain the matter-antimatter asymmetry in the universe for fitting dynamical properties of the phase transition and the bubble collisions result in gravitational waves.
To simulate the bubble dynamics we have developed a program that solves the non-equilibrium equations of motion in the so called *2PI-Formalism*. As a starting point we have simulated the dynamics of bubbles in a scalar $\lambda_4\phi^4 + \lambda_6\phi^6$ toy model in (1+1)-dimensions.

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Presenter: GARRATT, Thomas (Julius-Maximilians Universitaet Wuerzburg)

Session Classification: Parallel Track 3

Contribution ID: **26** Type: **Talk**

High temperature non-Abelian chiral instabilities in a lattice effective field theory

Thursday, 14 July 2016 15:00 (30 minutes)

The question of whether anomalous, i.e. CP-odd effects, in QCD have been observed in relativistic heavy-ion collisions is a topic of current theoretical and experimental interest. Its solution requires a deeper understanding of how CP-odd domains with chiral imbalance n5, if formed in the collision center, evolve in real-time.

Here we present recent results [1] on a new class of plasma instabilities so called chiral instabilities that may play a key role in the presence of finite n5. We investigate their existence and dynamics in non-Abelian SU(2) gauge theory implemented via a Langevin-like anomalous effective field theory [2] on the lattice. n5 enters as a dynamical degree of freedom, driven by changes in topology.

We find that fluctuations in the gauge fields indeed initiate a rapid energy transfer into the magnetic degrees of freedom, while depleting the chiral imbalance. At the same time the topological charge, as helicity is conserved, shows a clear drift among vacuum sectors proportional to the initial n5, as well as a significantly enhanced diffusion constant, i.e. sphaleron rate.

[1] Y.Akamatsu, A.R., N.Yamamoto, JHEP 1603 (2016) 210
[2] Y.Akamatsu, N.Yamamoto, Phys.Rev. D90 (2014) 125031

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Presenter: Dr ROTHKOPF, Alexander (Institute for Theoretical Physics, Heidelberg University)

Session Classification: Parallel Track 2

Contribution ID: **27** Type: **Talk**

Towards a high statistics analysis of quarkonium at T>0 using NRQCD on realistic Nf=2+1 HISQ lattices

Wednesday, 13 July 2016 15:15 (30 minutes)

Lattice QCD has has the potential to provide urgently needed first principles insight into the binding properties of heavy quarkonium in-medium, which form a central pillar of the experimental investigations of the quark-gluon plasma at the RHIC and LHC collider facilities.

Here we report on progress in our ongoing work to deploy the effective field theory NRQCD on current generation dynamical QCD lattices with Nf=2+1 light HISQ flavors at T>0, in order to ultimately extract the in-medium spectral properties of bbar and ccbar bound states around the phase transition and in the QGP regime.

In addition to previously published results on Bottomonium [1], we have investigated both correlator and spectral properties of Charmonium states [2] which showed a clear ordering of their in-medium modification, also among different flavors, according to the vacuum binding energy. Both computations are currently being extended [3] to higher temperatures, preliminary results of which are presented on this poster.

[1] S.Kim, P.Petreczky, A.R. Phys.Rev. D91 (2015) 054511
[2] S.Kim, P.Petreczky, A.R. arXiv:1511.04151, arXiv:1512.05289
[3] S.Kim, P.Petreczky, A.R. in preparation

Primary authors: Dr ROTHKOPF, Alexander (Institute for Theoretical Physics, Heidelberg University); Dr PETRECZKY, Peter (Physics Department, Brookhaven National Laboratory, Upton, NY11973, USA); Prof. KIM, Seyong (Department of Physics, Sejong University, Seoul 143-747, Korea)

Presenter: Dr ROTHKOPF, Alexander (Institute for Theoretical Physics, Heidelberg University)

Session Classification: Parallel Track 2

Contribution ID: **28** Type: **Talk**

scale invariant resummed perturbation at finite temperature

Wednesday, 13 July 2016 14:45 (30 minutes)

We will illustrate how a nonperturbative variational technique combined with renormalization group (RG) properties efficiently resums perturbative expansions in thermal field theories. The resulting convergence and scale dependence of optimized thermodynamical quantities are drastically improved as compared to standard perturbative expansions, as well as to other related methods such as the screened perturbation or (resummed) hard-thermal-loop perturbation. Our general method will be illustrated for the scalar phiˆ4 model, and we will discuss also how it can be generalized to QCD.

Primary author: KNEUR, Jean-Loic (Univ Montpellier)

Presenter: KNEUR, Jean-Loic (Univ Montpellier)

Session Classification: Parallel Track 2

Contribution ID: **29** Type: **Talk**

Lessons from Numerical Holography

Friday, 15 July 2016 11:45 (45 minutes)

Gauge/gravity duality (or "holography") allows one to calculate highly non-trivial far from equilibrium dynamics in strongly coupled gauge theory — provided one can solve asymptotically anti-de Sitter initial value problems in higher dimensional gravity. Recent results and work in progress in this area will be discussed, focusing on calculations motivated by the physics of heavy ion collisions and thermal gauge theories.

Primary author: YAFFE, Laurence (University of Washington)

Co-author: CHESLER, Paul (Harvard)

Presenter: YAFFE, Laurence (University of Washington)

Session Classification: Plenary

Contribution ID: **30** Type: **Talk**

Renormalization of ϕ^4-theory in the 2PI Hartree approximation scheme for non-vanishing background field

Tuesday, 12 July 2016 14:30 (30 minutes)

In the study of phase transitions in the early universe, methods based on N particle irreducible effective actions have become very important for describing the out of equilibrium dynamics of these phenomena. Equations of motion for classical 1-, up to N-point functions can be obtained from stationarity conditions. However, in order to extract physical information, the action must first be renormalized. Self-consistent schemes for doing so have been presented in the literature. Typically, when performing the renormalization, it is assumed that the classical field vanishes. We have adopted the renormalization procedure presented by Berges et al. [arXiv:hep-ph/0503240], applying it to a ϕ^4 toy model and explicitely perform the renormalization in the Hartree approximation, assuming a non-vanishing classical field.

Primary author: GROSS, Christoph (Julius-Maximilians Universität Würzburg)

Co-author: Prof. POROD, Werner (Julius-Maximilians Universität Würzburg)

Presenter: GROSS, Christoph (Julius-Maximilians Universität Würzburg)

Session Classification: Parallel Track 3

Contribution ID: **31** Type: **Talk**

Complex Langevin Dynamics for a Random Matrix Model of QCD at finite density

Thursday, 14 July 2016 14:30 (30 minutes)

We study a Random Matrix Model for QCD at finite density via Complex Langevin dynamics. This model has a phase transition to a phase with non-zero baryon density. We study the convergence of the algorithm as a function of the quark mass and the chemical potential and focus on two main observables: the baryon density and the chiral condensate. As expected, for simulations close to the chiral limit, the algorithm has wrong convergence properties when the quark mass is in the spectral domain of the quenched Dirac operator. Possible solutions of this problem are discussed.

Primary author: Dr ZAFEIROPOULOS, Savvas (Goethe University of Frankfurt)

Co-authors: Prof. VERBAARSCHOT, Jacobus (Stony Brook University); GLESAAEN, Jonas Rylund; PHILIPSEN, Owe (Goethe-University Frankfurt)

Presenter: Dr ZAFEIROPOULOS, Savvas (Goethe University of Frankfurt)

Session Classification: Parallel Track 3

Contribution ID: **32** Type: **Talk**

Perturbative study of the QCD phase diagram for heavy quarks at nonzero chemical potential

Wednesday, 13 July 2016 14:15 (30 minutes)

We investigate the phase diagram of QCD with heavy quarks at finite temperature and chemical potential in the context of background field methods. In particular, we use a massive extension of the Landau-DeWitt gauge which is motivated by previous studies of the deconfinement phase transition in pure Yang-Mills theories. We show that a simple one-loop calculation is able to capture the richness of the phase diagram in the heavy quark region, both at real and imaginary chemical potential. Moreover, dimensionless ratios of quantities directly measurable in numerical simulations are in good agreement with lattice results.

Primary author: SERREAU, Julien (Université Paris Diderot)

Co-authors: Dr TISSIER, Matthieu (Université Pierre et Marie Curie); Dr REINOSA, Urko (École Polytechnique - Palaiseau)

Presenter: SERREAU, Julien (Université Paris Diderot)

Session Classification: Parallel Track 2

Contribution ID: **33** Type: **Talk**

Self-consistent solitons for tunneling transitions

Thursday, 14 July 2016 14:30 (30 minutes)

In many models of electroweak symmetry breaking, the vacuum structure depends crucially on radiative effects. In order to compute the decay rate of metastable states, the loop corrections must therefore be accounted for in the tunneling solitons. In turn, the loops depend on the solitonic background, such that self-consistent solutions must be found. We will discuss the relevance of this problem for the finding lifetime of the Standard Model vacuum as well as the development of methods of resolving this problem. (based on 1509.08480, 1509.07847, 1501.07466)

Primary author: Prof. GARBRECHT, Björn (TU München)

Presenter: Prof. GARBRECHT, Björn (TU München)

Session Classification: Parallel Track 2

Contribution ID: **34** Type: **Talk**

Standard Model vacuum decay and non-minimal coupling.

Thursday, 14 July 2016 13:30 (30 minutes)

I will discuss the effect of including a non-minimal coupling between the Higgs field and gravity on vacuum decay in the Standard Model. High precision numerical results indicate that this suppresses vacuum decay relative to flat space calculations, with the minimal suppression near the conformal value of the coupling, $\xi = 1/6$, due to the near-conformal symmetry of the large field 3-loop effective potential. The effect with back-reaction alone, and no non-minimal coupling ($\xi = 0$), produces an almost negligible shift in the stability bounds for the Standard Model.

Primary authors: RAJANTIE, Arttu (Imperial College Sci., Tech. & Med. (GB)); STOPYRA, Stephen (Imperial College London)

Presenter: STOPYRA, Stephen (Imperial College London)

Session Classification: Parallel Track 2

Contribution ID: **35** Type: **Talk**

Semi-holography for heavy ion collisions

Tuesday, 12 July 2016 13:30 (30 minutes)

I will present the recent developments [JHEP05(2016)141] of the semi-holographic model first proposed in [JHEP06(2015)003]. The semi-holographic approach makes it possible to combine Color Glass Condensate initial conditions and weak-coupling glasma field equations with a simultaneous evolution of a strongly coupled infrared sector describing the soft gluons radiated by hard partons. The new developments presented here include self-consistent couplings between the CGC framework and an infrared AdS/CFT sector, such as to guarantee the existence of a conserved energy-momentum tensor for the combined system that is local in space and time. Moreover, we include a coupling of the topological charge density in the glasma to the same of the soft sector. As a first numerical test of a of the iterative numerical procedure suggested earlier we study the dynamics of fluctuating homogeneous color-spin-locked Yang-Mills fields when coupled to a homogeneous and isotropic energy-momentum tensor of the soft sector.

Primary author: Mr PREIS, Florian (Technische Universität Wien)

Co-authors: Prof. REBHAN, Anton (Technische Universität Wien); MUKHOPADHYAY, Ayan (Technische Universität Wien); STRICKER, Stefan (Technische Universität Wien)

Presenter: Mr PREIS, Florian (Technische Universität Wien)

Session Classification: Parallel Track 2

Contribution ID: **36** Type: **Talk**

Early quark production and approach to chemical equilibrium

Thursday, 14 July 2016 17:30 (30 minutes)

We present results from real-time lattice simulations of out-of-equilibrium quark production in non-Abelian gauge theory in 3+1-dimensions. Our simulations include the backreaction of quarks onto the dynamical gluon sector, which is particularly relevant for strongly correlated quarks. We observe fast isotropization and universal behavior of quarks and gluons at weak coupling and establish a quantitative connection to previous pure glue results. In order to understand the strongly correlated regime, we perform simulations for a large number of flavors and compare them to those obtained with two light quark flavors. By doing this we are able to provide estimates of the chemical equilibration time. The presentation is based on our recent publication in Phys. Rev. D93 no. 8, (2016) 085001, arXiv:1601.03576.

Primary author: Dr GELFAND, Daniil (Vienna University of Technology)

Co-authors: Dr HEBENSTREIT, Florian (University of Bern); BERGES, Jürgen (Heidelberg University)

Presenter: Dr GELFAND, Daniil (Vienna University of Technology)

Session Classification: Parallel Track 2

Contribution ID: **37** Type: **Talk**

Decay Rate of Right-Handed Neutrinos in Light of Collective Excitations at Electroweak Scale

Wednesday, 13 July 2016 14:15 (30 minutes)

The origin of the baryon asymmetry in the Universe (BAU) is a big mystery in particle physics and cosmology. One interesting scenario to explain BAU is the resonant leptogenesis which admits lepton number creation in the electroweak-scale, and therefore, receives lots of phenomenological interests in the LHC era. Then, the decay of right-handed neutrinos which causes the lepton number must be evaluated in the electroweak-scale plasma, where non-trivial collective excitations emerge due to co-existence of a mass scale induced by the Higgs mechanism and temperature. We investigate the decay rate of right-handed neutrinos with respect to such collective modes providing novel decay channels for the right-handed neutrinos. The collective excitation has been well investigated in the physics of the quark-gluon plasma (QGP), and the subject in this presentation would provide a bridge between the leptogenesis and the QGP community.

Primary author: Dr MIURA, Kohtaroh (CPT, Aix-Marseille Universite)

Co-author: Prof. KUNIHIRO, Teiji (Department of Physics, Kyoto University)

Presenter: Dr MIURA, Kohtaroh (CPT, Aix-Marseille Universite)

Session Classification: Parallel Track 3

Contribution ID: **38** Type: **Talk**

Dijet production as a probe of dense partonic system

Tuesday, 12 July 2016 13:30 (30 minutes)

In order to investigate structure of Pb nuclei at high energies we study forward dijet production in p-Pb hadronic collisions.
We propose a framework for evaluating cross section for production of forward dijets that encompasses Color Glass Condensate and high energy factorization effects and is therefore applicable regardless of the magnitude of transversal momenta of produced jets.
The framework is based on the generalization of the Transversal Momentum Dependent Factorization formula for dijet production.
Furthermore we provide fenomenological results for nuclear modification ratios using the developed framework.

Primary author: KUTAK, Krzysztof (Instytut Fizyki Jadrowej Polskiej Akademii Nauk)

Presenter: KUTAK, Krzysztof (Instytut Fizyki Jadrowej Polskiej Akademii Nauk)

Session Classification: Parallel Track 1

Contribution ID: **39** Type: **Talk**

Simulating thick pancake collisions

Thursday, 14 July 2016 17:00 (30 minutes)

A common simplification for describing the early stages of heavy ion collisions is the assumption that incoming nuclei are Lorentz-contracted to infinitely thin "pancakes". This leads to boost-invariance of the produced glasma-state and reduces the system to effectively 2+1 dimensions. This assumption is less justified at lower collision energies. In a recent work \1 we showed how to allow for a finite pancake thickness in the simulation of the production of a glasma state within the McLerran-Venugopalan model. This is achieved by using the colored particle-in-cell (CPIC) method in the laboratory frame. We verify that this method agrees with boost-invariant approaches for thin nuclei and find deviations in observables like the pressure anisotropy for thicker nuclei.

\1 D. Gelfand, AI, D. Müller, arXiv:1605.07184

Primary author: IPP, Andreas (TU Wien)

Co-authors: GELFAND, Daniil (TU Wien); MÜLLER, David (TU Wien)

Presenter: IPP, Andreas (TU Wien)

Session Classification: Parallel Track 2

Contribution ID: **40** Type: **Talk**

Standard Model thermodynamics across the electroweak crossover

Thursday, 14 July 2016 14:00 (30 minutes)

Within the Standard Model there is no electroweak phase transition which could account for the non-equilibrium physics needed for Baryogenesis. Nevertheless, at temperatures around 160 GeV some interesting features in the equation of state and other thermodynamical functions, e.g. the heat capacity, can be observed. These features of the Standard Model background could have an impact on non-equilibrium BSM physics, e.g. leptogenesis scenarios or dark matter particle production, taking place at this crossover temperature. In a perturbative three-loop computation and by using already existing lattice simulation data in a dimensionally reduced effective field theory we estimate the relevant thermodynamical functions across the crossover.

Primary authors: MEYER, Manuel (Universität Bern); LAINE, Mikko Sakari (Universitaet Bern (CH))

Presenter: MEYER, Manuel (Universität Bern)

Session Classification: Parallel Track 1

Contribution ID: **41** Type: **Talk**

Collisions in Non-conformal Theories: Hydrodynamization without Equilibration

Tuesday, 12 July 2016 14:30 (30 minutes)

Ever since fast hydrodynamization has been observed in heavy ion collisions the understanding of the very early non-equilbrium stage of such collisions has been a topic of intense research. We use the gauge/string duality to model the creation of a strongly coupled Quark-Gluon plasma in a non-conformal gauge theory. We focus on new physics (as compared to the conformal case) such as the non-trivial equation of state and the presence of a sizeable bulk viscosity. Non-conformality gives rise to an increase of the relaxation times of the resulting plasma. Furthermore, if the bulk viscosity is large enough then the plasma becomes well described by hydrodynamics before the equilibrium equation of state becomes applicable.

Primary author: ATTEMS, maximilian (University of Barcelona)

Co-authors: Dr SOPUERTA, Carlos (ICE); Mr SANTOS, Daniel (ICREA); MATEOS, David (ICREA & U. Barcelona); CASALDERREY SOLANA, Jorge (University of Barcelona (ES)); ZILHÃO, Miguel; Mr TRIANA, Miquel (UB)

Presenter: ATTEMS, maximilian (University of Barcelona)

Session Classification: Parallel Track 2

Contribution ID: **42** Type: **Talk**

Leptogenesis in GeV seesaw models with large mixing angles

Wednesday, 13 July 2016 15:15 (30 minutes)

We consider the dynamics of the standard model extended by two or more right handed neutrinos, which simultaneously explains the origin of neutrino masses through the seesaw mechanism and the baryon asymmetry of the universe through leptogenesis.
Specifically, we focus on right handed neutrinos with GeV scale mass which can be found in collider or fixed target experiments.
We use quantum kinetic equations to calculate the baryon asymmetry produced through right-handed neutrino oscillations in the early universe, and predict their properties from the requirement to explain the observed baryon asymmetry of the universe.
By identifying the time scales of oscillations and equilibration, and comparing them we find two regimes of production.
The *oscillatory* regime, where the oscillations happen much earlier than the equilibration of the right handed neutrinos, which is suitable for calculating the baryon asymmetry for regions of parameter space where the mixing between the left- and right-handed neutrinos is small.
For large mixing angles we find the *overdamped* regime, where one of the right handed neutrinos typically reaches equilibrium before the oscillations among the right handed neutrinos begin.
We develop analytic approximations for each of the two regimes, and use them to derive predictions of the right handed neutrino properties if they are responsible for the origin of matter.

Primary authors: GARBRECHT, Bjorn; GUETER, Dario (Technische Universität München); Mr KLARIC, Juraj (Technische Universität München); DREWES, Marco (Technische Universitaet Muenchen (DE))

Presenter: Mr KLARIC, Juraj (Technische Universität München)

Session Classification: Parallel Track 3

Contribution ID: **43** Type: **Talk**

Superfluid vortices in dense quark matter

Thursday, 14 July 2016 17:30 (30 minutes)

Superfluid vortices in the color-flavor-locked (CFL) phase of dense quark matter are known to be energetically disfavored relative to well-separated triplets of so-called semi-superfluid color flux tubes. In this talk we will present results from our numerical stability analysis of superfluid vortices in dense quark matter. After identifying (physical) regions of metastability/instability in the parameter space of the couplings of our effective theory, we will discuss the structure of the unstable mode responsible for the decay in the case of vanishing gauge coupling. If a neutron star features a superfluid quark matter core, our analysis indicates that it is very likely that it would contain semi-superfluid vortices rather than superfluid vortices. We will point out possible implications of our results to neutron stars.

Primary authors: WINDISCH, Andreas (Washington University in St Louis); ALFORD, Mark (Washington University, St Louis); MALLAVARAPU, S. Kumar (Washington University in St. Louis); VACHASPATI, Tanmay (Arizona State University)

Presenter: WINDISCH, Andreas (Washington University in St Louis)

Session Classification: Parallel Track 3

Contribution ID: **44** Type: **Talk**

Chiral magnetic effect by synthetic gauge fields

Thursday, 14 July 2016 16:30 (30 minutes)

The chiral magnetic effect has attracted much interest in various areas of physics from condensed matter physics to nuclear and particle physics.
In condensed matter physics it has actively investigated in the so called Weyl (semi-)metals in which Weyl fermions are realized as points of band touching with definite topological character.
The chiral magnetic effect arises only in nonequilibrium.
It needs finite chiral chemical potential, which equals the mismatch of the Fermi surfaces of right- and left-handed Weyl fermions.
The mismatch (chiral chemical potential) does not appear in equilibrium and is only dynamically generated.
However the dynamics of the chiral chemical potential has not been fully understood yet, which is important to understand the physics of anomaly induced transports in the chiral systems.

We study the dynamical generation of the chiral chemical potential in a Weyl metal in a three-dimensional optical lattice system, which will be realized by using ultracold atom gases.
Even though atoms are neutral and do not interact with electromagnetic fields, we can simulate the chiral magnetic effect by using ultracold atoms thanks to the so called synthetic gauge fields.
By numerically solving the Boltzmann equation with the Berry curvature in the presence of parallel synthetic electric and magnetic fields,
we analyze the time evolution of the chiral chemical potential and the chiral magnetic current.

Primary author: Dr HAYATA, Tomoya (Chuo University)

Co-author: Prof. UEDA, Masahito (University of Tokyo)

Presenter: Dr HAYATA, Tomoya (Chuo University)

Session Classification: Parallel Track 3

Contribution ID: **45** Type: **Talk**

Active and sterile neutrino dynamics below the electroweak crossover

Wednesday, 13 July 2016 13:45 (30 minutes)

I will summarize a recent estimation (arXiv:1605.07720) of the thermal masses and damping rates of active (m < eV) and sterile (M ~ GeV)
neutrinos with thermal momenta k ~ 3T at temperatures below the electroweak crossover
(5 GeV < T < 160 GeV). These quantities in turn fix the washout rates of Standard
Model lepton number densities and the thermal production rate of sterile neutrinos. These interact via direct scatterings mediated
by Yukawa couplings, and via their overlap with active neutrinos. I will review the calculation, which includes all leading order reactions. I will show that the resulting washout rate generally exceeds the Hubble rate for 5 GeV
< T < 30 GeV. Therefore it is challenging to generate a large lepton asymmetry facilitating dark matter computations operating at T < 5 GeV, whereas the generation of a baryon asymmetry at T > 130 GeV remains an option.

Primary author: GHIGLIERI, Jacopo (Universitaet Bern (CH))

Presenter: GHIGLIERI, Jacopo (Universitaet Bern (CH))

Session Classification: Parallel Track 3

Contribution ID: **46** Type: **Talk**

Symmetry breaking restoration by acceleration

Thursday, 14 July 2016 15:00 (30 minutes)

In this work we consider the ontological status of the Unruh effect. Is it just a formal mathematical result? Or the temperature detected by an accelerating observer can lead to real physical effects such as phase transitions? In order to clarify this issue we use the Thermalization Theorem to explore the possibility of having a restoration of the symmetry in a system with spontaneous symmetry breaking of an internal continuous symmetry as seen by an accelerating observer. We conclude that the Unruh effect is real physical effect rather than a formal result, giving rise, in the particular example considered here, to a phase transition (symmetry restoration) in the region close to the accelerating observer horizon. We apply our results also to the region close to BH horizons.

Primary author: DOBADO GONZALEZ, ANTONIO

Presenter: DOBADO GONZALEZ, ANTONIO

Session Classification: Parallel Track 3

Contribution ID: **47** Type: **Talk**

Baryons across the deconfinement transition

Wednesday, 13 July 2016 13:45 (30 minutes)

Surprisingly, unlike mesonic correlators, baryonic correlators at nonzero temperature have only been studied in a handful of studies. Here we present a lattice study of baryonic correlators and spectral functions across the deconfinement transition, using FASTSUM's 2+1 Wilson ensembles. We present results for in-medium effects below Tc and parity doubling above Tc.

Primary author: AARTS, Gert (Swansea University)

Presenter: AARTS, Gert (Swansea University)

Session Classification: Parallel Track 1

Contribution ID: **48** Type: **Talk**

Dense 2-colour QCD towards the continuum limit

Wednesday, 13 July 2016 14:15 (30 minutes)

We report on simulations of 2-colour QCD with Nf=2 Wilson fermions at nonzero chemical potential and temperature. We present results for the diquark condensate, Polyakov loop and quark number density on finer lattices than those previously reported, as well as ongoing simulations with smaller quark masses. Our results confirm the existence of a "quarkyonic" phase at high density, while the putative low-temperature, high-density deconfinement transition appears to recede as the continuum limit is approached. There are indications of a BEC region opening up at intermediate chemical potentials as the quark mass is lowered.

Primary author: SKULLERUD, Jon-Ivar (National University of Ireland Maynooth)

Co-authors: GIUDICE, Pietro (Muenster University); HANDS, Simon (Swansea University); BOZ, Tamer (National University of Ireland Maynooth)

Presenter: SKULLERUD, Jon-Ivar (National University of Ireland Maynooth)

Session Classification: Parallel Track 1

Contribution ID: **49** Type: **Talk**

The Polyakov loop and correlator in perturbation theory

The Polyakov loop is related to the free energy of a static quark in thermal QCD and therefore an important theoretical tool for the study of the quark-gluon-plasma. The Polyakov loop correlator accordingly is related to the free energy of a static quark-antiquark pair in thermal QCD, and it is a very interesting quantity to investigate the interactions of static quarks and their modifications through the medium. We study both quantities in perturbation theory through direct calculations and effective field theories, presenting a new determination of the Polyakov loop at next-to-next-to-leading order. This new term of the Polyakov loop is sufficient to obtain one higher perturbative order of the Polyakov loop correlator, for which we will also discuss the decomposition in terms of color singlet and octet contributions. Finally, a comparison to lattice results will be given.

Based on: Physical Review D 93 03, 034010; arXiv:1512.08443 [hep-ph]

Primary author: BERWEIN, Matthias (TU Munich)

Co-authors: VAIRO, Antonio; BRAMBILLA, Nora; PETRECZKY, Peter (BNL)

Presenter: BERWEIN, Matthias (TU Munich)

Contribution ID: **50** Type: **Talk**

QCD critical point and thermal photons

Wednesday, 13 July 2016 14:45 (30 minutes)

The beam energy scan programs at BNL Relativistic Heavy Ion Collider open up a new opportunity to explore the quark-gluon plasma (QGP) at finite densities. The quantitative success of hydrodynamic modeling motivates one to extend the model to lower energies to verify its applicability, to study the transport properties at finite densities, and ultimately to understand the phase structure of QCD, including the long-sought critical point.

One of the problems in the search for the critical point is that its signal in hadronic observables would be washed away if its location is far from freeze-out even if it exists. In this work, we propose to study thermal photon spectra and elliptic flow at finite baryon density using a (2+1)-dimensional hydrodynamic model. We investigate a possible signal of the QCD critical point in those observables because it would be visible regardless of its location on the T-μ plane owing to the fact that the QGP medium is electromagnetically transparent.

Primary author: MONNAI, Akihiko (Institut de Physique Théorique, CNRS/CEA)

Presenter: MONNAI, Akihiko (Institut de Physique Théorique, CNRS/CEA)

Session Classification: Parallel Track 1

Contribution ID: **51** Type: **Talk**

Hydrodynamization in weakly-coupled heavy-ion collisions

Friday, 15 July 2016 11:00 (45 minutes)

I will discuss how hydrodynamical flow is reached in heavy-ion collisions in the limit of weak coupling using an effective kinetic theory description during the prethermal evolution. I present a Green function that can be used to provide an initial condition for a hydrodynamical simulation given the initial geometry.

Presenter: KURKELA, Eero Aleksi (CERN)

Session Classification: Plenary

Contribution ID: **52** Type: **Talk**

Vacuum (meta?)stability, Higgs inflation and physics beyond the Standard Model

Friday, 15 July 2016 09:00 (45 minutes)

The measurements of the Higgs mass and top quark Yukawa coupling indicate that we live in a very special Universe, at the edge of the absolute stability of the electroweak vacuum. The most precise theoretical computations combined with the most recent LHC experiments do not allow us to decide with certainty whether our vacuum is absolutely stable or metastable. In any event, the Standard Model (SM) can be extended all the way up to the Planck scale M_P in a self-consistent manner. Still, the SM cannot be a complete theory below M_P as it cannot explain the flatness and homogeneity of the Universe at large scales, existence of structures such as clusters or galaxies, its matter-antimatter asymmetry, the presence of dark matter and neutrino masses. The first set of problems can be solved within the SM if the Higgs field has a non-minimal coupling to gravity. I will discuss the Higgs inflation for both stable and metastable vacuum and show that it can take place even if the scalar Higgs self-coupling crosses zero at the energy scale much below the inflationary one. The second set of problems can be solved by extending the SM by three relatively light right-handed neutrinos. I will overview shortly the predictions of the model and discuss accelerator and astrophysical experiments which can be capable to test it.

Presenter: SHAPOSHNIKOV, Mikhail (EPFL)

Session Classification: Plenary

Contribution ID: **53** Type: **Talk**

Dense nuclear and quark matter in compact stars

Friday, 15 July 2016 09:45 (45 minutes)

I will review how compact stars can serve as a laboratory for
fundamental physics, and how the latest astrophysical data can be used to put constraints on the properties of dense QCD matter, for example on its equation of state and on hydrodynamical properties of nuclear and quark superfluids. In the second, more specific, part of the talk, I will present latest results on employing holographic methods to obtain a strong-coupling equation of state for both nuclear and quark matter
within a single model.

Presenter: SCHMITT, Andreas (University of Southampton)

Session Classification: Plenary

Contribution ID: **54** Type: **Talk**

Gravitational waves and eLISA

Thursday, 14 July 2016 09:00 (45 minutes)

Presenter: HINDMARSH, Mark (University of Sussex)

Session Classification: Plenary

Contribution ID: **55** Type: **Talk**

Jet evolution in dense QCD matter

Thursday, 14 July 2016 09:45 (45 minutes)

I discuss the physical picture for the evolution of a high-energy jet in a hot quark-gluon plasma, with emphasis on our latest results on this topic. A complete picture of jet evolution includes both coherent gluon emissions and incoherent emissions. We find a double logarithmic contribution from coherent gluon emissions. The resummation of such leading double logs can be absorbed into a renormalized transport coefficient \hat{q} (the celebrated jet quenching coefficient). Such a radiative correction significantly enhances the value of \hat{q}, with important consequences for the studies of jet quenching in ultra-relativistic heavy-ion collisions. In the second part of my talk, I discuss the jet evolution via incoherent multiple branching and thermalization of the soft branching products. I argue that the following scenario should hold: the leading particle emits a significant number of mini-jets which promptly evolve via multiple branchings and thus degrade into a myriad of soft gluons, with energies of the order of the medium temperature T. Via elastic collisions with the medium constituents, these soft gluons relax to local thermal equilibrium with the plasma over a time scale which is considerably shorter than the typical lifetime of the mini-jet. The thermalized gluons form a tail which lags behind the hard components of the jet.

Presenter: WU, Bin (Ohio State)

Session Classification: Plenary

Contribution ID: **56** Type: **Talk**

Leptogenesis

Thursday, 14 July 2016 11:00 (45 minutes)

Presenter: BÖDEKER, Dietrich (Bielefeld University)

Session Classification: Plenary

Contribution ID: **57** Type: **Talk**

Background magnetic fields and the QCD phase diagram

Thursday, 14 July 2016 11:45 (45 minutes)

Strongly interacting quarks and gluons exposed to a background magnetic field reveal a rich physical structure. This topic has recently become of interest, both because it challenges our understanding of the underlying theory (QCD) as well as due to a wide range of phenomenological applications, from neutron star physics to heavy-ion collisions.

A particularly interesting aspect of this theory is the response of the order parameter (the quark condensate) to the magnetic field and the structure of the corresponding phase diagram. In this talk, I summarize our current knowledge about the mechanisms that are relevant for this response within a variety of settings: effective theories, low-energy models of QCD and lattice QCD simulations.

Presenter: ENDRŐDI, Gergely (University of Frankfurt)

Session Classification: Plenary

Contribution ID: **58** Type: **Talk**

Probes of the Electroweak Phase Transition and Baryogenesis at the LHC

Monday, 11 July 2016 17:00 (45 minutes)

Uncovering the nature of the electroweak (EW) phase transition in the early Universe would be key to shed light on the possible origin of the cosmic matter-antimatter asymmetry. We discuss various ways in which searches for new physics beyond the Standard model at the LHC can be used to probe the nature of the EW phase transition, and their implications for the generation of the baryon asymmetry of the Universe at the EW scale.

Presenter: NO, Jose Miguel (University of Sussex)

Session Classification: Plenary

Contribution ID: **59** Type: **Talk**

EFT and its applications in cosmology

Wednesday, 13 July 2016 11:15 (45 minutes)

Presenter: CREMINELLI, Paolo (ICTP)

Session Classification: Plenary

Contribution ID: **60** Type: **Talk**

Topological transport phenomena in strong and electroweak matter

Wednesday, 13 July 2016 12:00 (45 minutes)

Chirality of fermions has a topological nature. This microscopic property modifies the macroscopic hydrodynamic behavior and leads to unusual transport phenomena protected by topology in relativistic systems. We show how conventional kinetic theory should be modified to take into account such effects. We also discuss their potential importance in strong and electroweak matter, and, in particular, in the evolution of supernovae.

Presenter: YAMAMOTO, Naoki (Keio University)

Session Classification: Plenary

Contribution ID: **61** Type: **Talk**

Geometric picture for scattering amplitudes

Tuesday, 12 July 2016 09:00 (45 minutes)

There has been a growing evidence that the standard formulation of Quantum Field Theory using path integrals and Feynman diagrams fails to explain unexpected simplicity and hidden symmetries of the scattering amplitudes. I show that in a certain gauge theory there exists a radically different picture for amplitudes as volumes of "Amplituhedron" which is a higher-dimensional generalization of convex polygons. I will also comment on the extension of this approach to other theories.

Presenter: TRNKA, Jaroslav (UC Davis)

Session Classification: Plenary

Contribution ID: **62** Type: **Talk**

Electroweak baryogenesis from dynamical CKM matrix

Tuesday, 12 July 2016 09:45 (45 minutes)

There are good motivations to consider that the flavour structure could emerge during electroweak symmetry breaking, for example if the Froggatt-Nielsen field dynamics were linked to the Higgs field. Remarkably, the the nature of the electroweak phase transition is completely changed when the Standard Model Yukawas vary at the same time as the Higgs is acquiring its vacuum expectation value, starting from order one values in the symmetric phase to reach their present values at the end of the phase transition. The thermal contribution of the fermions creates a barrier between the symmetric and broken phase minima of the effective potential, leading to a first-order electroweak phase transition. Besides, in this framework, the CKM matrix is the unique and sufficient CP-violating source for baryogenesis. This offers new routes for generating the baryon asymmetry at the electroweak scale, strongly tied to flavour models.

Presenter: SERVANT, Geraldine (Deutsches Elektronen-Synchrotron (DE))

Session Classification: Plenary

Contribution ID: **63** Type: **Talk**

The first Fermi of a Heavy-Ion Collision: results, puzzles, and opportunities

Tuesday, 12 July 2016 11:00 (45 minutes)

Presenter: VENUGOPALAN, Raju (Brookhaven National Laboratory)

Session Classification: Plenary

Contribution ID: **64** Type: **Talk**

Vacuum stability and early universe physics

Tuesday, 12 July 2016 11:45 (45 minutes)

Stability of the electroweak vacuum in the very early universe is a novel probe of high energy physics. A key question
is whether new physics beyond SM is required to maintain stability against inflationary fluctuations of the Higgs field.
Here curvature couplings induced by radiative corrections in curved space play a crucial role. I review the topic and show
that curvature effects can keep the electroweak vacuum stable in the early universe without any new physics. I also comment
on the use of vacuum stability as a new test for SM extensions and discuss the observational imprints of inflationary
Higgs fluctuations.

Presenter: NURMI, Sami (University of Jyväskylä)

Session Classification: Plenary

Contribution ID: **65** Type: **Talk**

Overview of ATLAS & CMS: Experiments, Techniques, and Results

Monday, 11 July 2016 13:30 (1 hour)

Presenter: PETERSEN, Troels (NBI)

Session Classification: Plenary

Contribution ID: **66** Type: **Talk**

Recent results from the LHC heavy ion programme

Monday, 11 July 2016 14:30 (1 hour)

A brief overview of the ultra-relativistic heavy ion physics programme at the Large Hadron Collider at CERN will be given. Collisions of lead ions have been studied at a center-of-mass energy per nucleon of 2.76 TeV (run I), and, more recently, at 5.02 TeV (run II). The ultimate goal of heavy-ion collisions is the study of the properties of the deconfined and chirally restored state of matter known as the Quark-Gluon Plasma. Various probes are used to characterize the properties of the QGP - from collective effects and direct photons to heavy quarks and jets. Main highlights from run I and recent results from run II will be presented.

Presenter: ROHRICH, Dieter (Department of Physics & Technology-University of Bergen)

Session Classification: Plenary

Contribution ID: **67** Type: **Talk**

Axions: The Unfinished Business of QCD

Wednesday, 13 July 2016 09:45 (1 hour)

Presenter: WILCZEK, Frank (MIT)

Session Classification: Plenary

Contribution ID: **68** Type: **Talk**

Recent results on lattice QCD thermodynamics

Monday, 11 July 2016 16:00 (1 hour)

I review recent results on QCD thermodynamics from lattice simulations. In particular, I will focus on the QCD equation of state at zero and finite chemical potential, the curvature of the phase diagram and fluctuations of conserved charges. The latter will be compared to experimental data, to the purpose of extracting the chemical freeze-out temperature and chemical potential from first principles.

Presenter: RATTI, Claudia (University of Houston)

Session Classification: Plenary

Contribution ID: **69** Type: **Talk**

Simulating a first-order electroweak phase transition

Thursday, 14 July 2016 17:30 (30 minutes)

In various extensions of the Standard Model it is possible that the electroweak phase transition was first order. This would have been a violent process, involving the formation of bubbles and associated shock waves. The collision of these bubbles and shock waves could be a detectable source of gravitational waves. I will summarise the current status of efforts to model the such a phase transition based on large-scale hydrodynamical simulations. From the nucleation of bubbles through to the onset of turbulence, I will discuss the processes involved, the dependence upon particular models, and the implications for detectability of the resulting gravitational wave power spectrum.

Presenter: WEIR, David (University of Stavanger)

Session Classification: Parallel Track 1

Contribution ID: **70** Type: **Talk**

Analytic gravitational wave spectrum from bubble collisions

Thursday, 14 July 2016 17:00 (30 minutes)

We consider gravitational wave production by bubble collisions during a cosmological first-order phase transition. Based on so-called thin-wall and envelope approximations, we estimate gravitational wave spectrum by an analytic way. Our estimation is based on the observation that the two-point correlator of the energy-momentum tensor can be expressed analytically under these assumptions.

Presenter: TAKIMOTO, Masahiro (KEK)

Session Classification: Parallel Track 1