Emergent Symmetries in Particle Physics, Cosmology and Condensed Matter Systems

Report of Contributions

https://indico.nbi.ku.dk/e/emsym

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

Carlos Hoyos

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

Igor Herbut: ”Fixed point collisions and tensor order parameters in Luttinger semimetals and some popular field theories”

Wednesday, 20 June 2018 10:00 (45 minutes)

Luttinger semimetals are ubiquitous electronic systems that have their chemical potential right at the point where two bands touch quadratically. They can be understood as higher-spin cousins of the better-known Weyl semimetals, and turn out to be more susceptible to effects of electron-electron interaction. I will discuss the possibility of a non-trivial scale-invariant infrared fixed point in these materials and introduce a general mechanism that works against it.

It will be argued that this mechanism with its concomitant separation of energy scales is also operative in low-dimensional QED, and responsible

for the notorious phenomenon of chiral symmetry breaking below the critical number of fermionic components. Finally, the notion of spin-two (nematic) order parameter which arises naturally in Lutinger semimetals will suggest a possible new path towards UV-complete O(N) field theories above four dimensions.

Key words: quantum phase transitions, scale invariance, fixed points, QED3, UV completion, Dirac systems, non-Fermi liquid, triviality

Session Classification: Morning session

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

Carlos Hoyos: ”Impurities and holography”

Wednesday, 20 June 2018 11:15 (45 minutes)

The Sachdev-Ye-Kitave model (SYK) and generalizations consist of quantum mechanical theories with an emergent conformal symmetry in the IR. It has been proposed that these theories serve as toy models of black holes in an emergent holographic dual description. I review the main features of this proposal and discuss similarities between SYK models and other systems such as magnetic impurities and Wilson loops.

Session Classification: Morning session

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

Jelle Hartong: ”Fluid Dynamics for Systems without Boost Invariance”

Wednesday, 20 June 2018 12:00 (45 minutes)

There are many systems in physics whose hydrodynamic limit requires a formulation of fluid dynamics in the absence of boost symmetries. Such a theory of hydrodynamics has so far not been considered in generality. In this talk I will present this theory for perfect fluids, and then generalize it to include first order transport coefficients such as viscosities and conductivities. It will be shown that linearized perturbations around a charged perfect fluid at rest, that obey the Onsager relations, contain 5 dissipative transport coefficients (3 conductivities, 2 viscosities) and one non-dissipative transport coefficient. Special attention will be given to the properties of scale invariant fluids with generic dynamical exponent z. In particular I will present a nogo theorem that states that perfect fluids with z\neq 1,2 cannot be boost invariant.

Keywords:

Fluids without boost symmetry, dynamical scaling vs. boost invariance, speed of sound for a non-boost invariant fluid with dynamical scaling, gas of free Lifshitz particles, new transport coefficients

Session Classification: Morning session

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

Jan de Boer: ”Emergent symmetries in AdS/CFT”

Wednesday, 20 June 2018 14:15 (45 minutes)

It is possible to derive effective actions for fluids using the AdS/CFT correspondence. Recent work on effective actions for fluids has suggested that these actions should be governed by new, somewhat
mysterious symmetries. In this talk I will try to explain a possible gravitational origin of these symmetries.

Session Classification: Afternoon session

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

Netta Engelhardt: ”Emergent Causality in Holography”

Wednesday, 20 June 2018 15:30 (45 minutes)

I will discuss an approach to indeed the emergence of causality from a new construct, the causal density matrix. This framework provides a sufficient and necessary condition for a quantum field theory to have a holographic dual with semi classical causal structure. I will discuss several applications of the causal density matrix.

Session Classification: Afternoon session

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

Roderich Moessner: ”An Ising model with emergent U(1) gauge field and SU(2) symmetry”

Thursday, 21 June 2018 10:00 (45 minutes)

Session Classification: Morning session

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

Michele Burrello: ”Topological Semimetals in Artificial Gauge Potentials”

Friday, 22 June 2018 11:45 (30 minutes)

In the last years, several research groups worldwide managed to reproduce the physics of Weyl fermions and to obtain the exotic features of topological semimetals in different condensed matter setups, including not only solid state compounds, but also photonic crystals. In this talk I will introduce the main features of these gapless 3D topological states of matter and I will focus on alternative realizations of Weyl semimetals based on a model for ultracold atoms in the presence of artificial magnetic fluxes in a cubic lattice. In these condensed matter systems, the emergent Lorentz invariance can be violated, and I will discuss some of the main examples of topological semimetals going beyon the standard Weyl case.

Session Classification: Morning session

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

Sung-Sik Lee: ”Emergent gravity from relatively local Hamiltonians”

Thursday, 21 June 2018 11:45 (45 minutes)

Keywords : gravity from quantum matter, emergent locality

Session Classification: Morning session

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

Marika Taylor: ”Holography beyond conformality”

Thursday, 21 June 2018 14:00 (45 minutes)

The original examples of dualities between gravity and quantum field theories involved conformal field theories, both in conformal phases and in spontaneously/explicitly broken symmetry phases. In this talk we will discuss geometric duals of irrelevant deformations of conformal field theories. While generically irrelevant deformations are viewed as being uncontrolled, holography picks out various classes of irrelevant deformations for which precise descriptions are possible. We will describe these and then discuss various applications of such holographic theories.

Session Classification: Afternoon session

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

Coffee

Session Classification: Afternoon session

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

John Toner: ”Fish Gotta swim, birds gotta fly, I gotta do Feynmann graphs ’til I die: A continuum theory of flocking”

Thursday, 21 June 2018 15:15 (45 minutes)

Flocking - i.e., the collective motion of large numbers of self-propelled entities - provides a classic illustration of the differences between equilibrium and non-equilibrium systems. Like an equilibrium ferromagnet, a non-equilibrium flock breaks rotation invariance by spontaneously choosing a direction of motion. Unlike a ferromagnet, it can even do so in two dimensions, in apparent violation of the Mermin-Wagner theorem, which states that it is NOT possible to spontaneously break a continuous symmetry in two dimensions.

In this talk, I’ll describe a “hydrodynamic” theory of flocking, which resolves this apparent contradiction by demonstrating that flocks can spontaneously break rotation invariance in two dimensions. Furthermore, the theory shows that they do so by developing anomalous hydrodynamics, in which all correlation functions scale differently than predicted by the linearized version of the theory, for all spatial dimensions d<4. I’ll discuss numerous numerical experiments supporting this striking prediction.

Session Classification: Afternoon session

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

Raúl Carballo-Rubio: ”Emergence of gauge symmetries: a working example”

Friday, 22 June 2018 10:00 (45 minutes)

In this talk I will present an emergent theory of electromagnetism as
a working example of how gauge symmetries can emerge from systems with a priori no such symmetries. The theory is inspired by the physics of the superfluid phases of Helium 3. I will discuss the main ingredients of this concrete emergence mechanism and show how one can describe it from two slightly different perspectives.
Finally, I shall pass to discuss whether a similar mechanism could be behind the emergence of diffeomorphism invariance. This discussion is in direct correspondence with the possibility of constructing a theory of quantum gravity along the same ideas. I will mention some of the challenges still remaining to lead this program to completion.

Session Classification: Morning session

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

Kevin Grosvenor: ”Nonrelativistic Naturalness and the question of Emergent Lorentz Symmetry”

Friday, 22 June 2018 11:15 (30 minutes)

I will discuss our proposal for a nonrelativistic solution to the Higgs mass hierarchy problem, its dependence on the emergence of various shift symmetries, and the role it might play in the search for a nonrelativistic theory of particle physics in which Lorentz symmetry emerges at “low” energies.

Session Classification: Morning session

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

Ajit Balram: ”Particle-hole symmetry for composite fermions: An emergent symmetry in the fractional quantum Hall effect”

Thursday, 21 June 2018 11:15 (30 minutes)

The particle-hole (PH) symmetry of electrons is an exact symmetry of the Coulomb Hamiltonian confined to a specific Landau level, and its interplay with the formation of composite fermions (CFs) has attracted much attention of late. In this talk, I will describe an emergent symmetry in the fractional quantum Hall effect, namely, the PH symmetry of composite fermions, which relates states of CFs confined to a specific CF-Landau level termed Λ-level. Detailed calculations using the microscopic theory of CFs demonstrate the following for low-lying Λ levels: (i) The two-body interaction between CF particles is very similar, apart from a constant additive term and an overall scale factor, to that between CF holes in the same Λ level; and (ii) the three-body interaction for CFs is an order of magnitude smaller than the two-body interaction. Taken together, these results imply an approximate PH symmetry for composite fermions in low Λ levels, which is also supported by exact-diagonalization studies and available experiments. This symmetry is not present in the original electronic Coulomb Hamiltonian and owes its existence entirely to the formation of CFs. With increasing Λ-level index, the two-body and three-body pseudopotentials become comparable, but at the same time they both diminish in magnitude, indicating that the interaction between CFs becomes weak as we approach the half-filled Landau level.

Reference:
Particle-hole symmetry for composite fermions: An emergent symmetry in the fractional quantum Hall effect, Ajit C. Balram and J. K. Jain, Phys. Rev. B 96, 245142 (2017)

Keywords: fractional quantum Hall effect, vortices, composite fermions, particle-hole symmetry

Session Classification: Morning session

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

Welcome and Introduction to the NBIA: Andrew Jackson

Wednesday, 20 June 2018 09:50 (10 minutes)

Session Classification: Registration and Welcome