GGI Theory Lectures by Young Researchers - ThLYR 2021

Report of Contributions

https://agenda.infn.it/e/thlyr2021

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

Geometric Approach to Supergravity - Lecture 1

Thursday, March 25, 2021 11:00 AM (2 hours)

The construction of supergravity theories from the technical point of view is a non-trivial task. In particular, complications arise from the fact that fermionic representations are involved. It is therefore particularly useful to find an efficient method to deal with the technical labor in formulating supergravity theories. In these lectures, we will explore the geometric (aka rheonomic) approach to supergravity theories in superspace, which allows a complete geometrical interpretation of supersymmetry.

Primary author: RAVERA, Lucrezia (Politecnico di Torino (DISAT))

Presenter: RAVERA, Lucrezia (Politecnico di Torino (DISAT))

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

Geometric Approach to Supergravity - Lecture 2

Friday, March 26, 2021 11:00 AM (2 hours)

The construction of supergravity theories from the technical point of view is a non-trivial task. In particular, complications arise from the fact that fermionic representations are involved. It is therefore particularly useful to find an efficient method to deal with the technical labor in formulating supergravity theories. In these lectures, we will explore the geometric (aka rheonomic) approach to supergravity theories in superspace, which allows a complete geometrical interpretation of supersymmetry.

Primary author: RAVERA, Lucrezia (Politecnico di Torino (DISAT))

Presenter: RAVERA, Lucrezia (Politecnico di Torino (DISAT))

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

Cosmology and Geometry at the boundary - Lecture 1

Monday, April 12, 2021 11:00 AM (2 hours)

Cosmological observables, such as temperature fluctuations in the CMB and density fluctuations in the distribution of galaxies, can be traced back at the end of inflation where they are encoded in quantum correlations, and the wavefunction of the universe which generates them, at a space-like boundary of a quasi-dS space-time. These lectures will focus on a novel approach to construct the wavefunction of the universe from boundary data only and extract from them physical informations. We will learn about its analytic structure, the interpretation of the singuality coefficients as physical processes, including scattering processes in flat-space, as well as a first-principle formulation in terms of combinatorial-geometrical objects which, together to provide new computational tools, provide a window on the basic rules behind cosmological processes.

Primary author: BENINCASA, Paolo (Niels Bohr International Academy, IFT Madrid)

Presenter: BENINCASA, Paolo (Niels Bohr International Academy, IFT Madrid)

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

Cosmology and Geometry at the boundary - Lecture 2

Tuesday, April 13, 2021 11:00 AM (2 hours)

Cosmological observables, such as temperature fluctuations in the CMB and density fluctuations in the distribution of galaxies, can be traced back at the end of inflation where they are encoded in quantum correlations, and the wavefunction of the universe which generates them, at a space-like boundary of a quasi-dS space-time. These lectures will focus on a novel approach to construct the wavefunction of the universe from boundary data only and extract from them physical informations. We will learn about its analytic structure, the interpretation of the singuality coefficients as physical processes, including scattering processes in flat-space, as well as a first-principle formulation in terms of combinatorial-geometrical objects which, together to provide new computational tools, provide a window on the basic rules behind cosmological processes.

Primary author: BENINCASA, Paolo (Niels Bohr International Academy, IFT Madrid)

Presenter: BENINCASA, Paolo (Niels Bohr International Academy, IFT Madrid)

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

Aspects of Generalized Global Symmetries and Anomalies - Lecture 1

Tuesday, May 11, 2021 4:00 PM (2 hours)

I will review some recent results on the dynamics of quantum field theories based on a renewed understanding of global symmetries and their anomalies.

Primary author: TIZZANO, Luigi (Simons Center for Geometry and Physics, SUNY, Stony Brook, NY)

Presenter: TIZZANO, Luigi (Simons Center for Geometry and Physics, SUNY, Stony Brook, NY)

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

Aspects of Generalized Global Symmetries and Anomalies - Lecture 2

Thursday, May 13, 2021 4:00 PM (2 hours)

I will review some recent results on the dynamics of quantum field theories based on a renewed understanding of global symmetries and their anomalies.

Primary author: TIZZANO, Luigi (Simons Center for Geometry and Physics, SUNY, Stony Brook, NY)

Presenter: TIZZANO, Luigi (Simons Center for Geometry and Physics, SUNY, Stony Brook, NY)

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

Defects in conformal field theory and holography - Lecture 1

Thursday, May 27, 2021 11:00 AM (2 hours)

The general study of defects has relations with the physics of almost every field theory. Defects can be introduced into a conformal field theory as means to make contact with the real world, reducing the total amount of symmetry. The broken conformal symmetries relax some of the constraints put on the correlation functions and defects can be used as probes to study the dynamics of a theory. In the first part of these lectures, I will give some hints on the bootstrap program for defect conformal field theories. Furthermore, I will focus on a particular defect version of N=4 Super Yang-Mills which has a holographic realization in terms of a D3-probe-D5 brane system. In this setup, I will present some particular results for local and non-local observables achieved with different techniques.

Primary author: BONANSEA, Sara (Niels Bohr Institute, Copenhagen University)

Presenter: BONANSEA, Sara (Niels Bohr Institute, Copenhagen University)

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

Defects in conformal field theory and holography - Lecture 2

Friday, May 28, 2021 11:00 AM (2 hours)

The general study of defects has relations with the physics of almost every field theory. Defects can be introduced into a conformal field theory as means to make contact with the real world, reducing the total amount of symmetry. The broken conformal symmetries relax some of the constraints put on the correlation functions and defects can be used as probes to study the dynamics of a theory. In the first part of these lectures, I will give some hints on the bootstrap program for defect conformal field theories. Furthermore, I will focus on a particular defect version of N=4 Super Yang-Mills which has a holographic realization in terms of a D3-probe-D5 brane system. In this setup, I will present some particular results for local and non-local observables achieved with different techniques.

Primary author: BONANSEA, Sara (Niels Bohr Institute, Copenhagen University)

Presenter: BONANSEA, Sara (Niels Bohr Institute, Copenhagen University)

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

Primordial gravitational waves and interferometers - Lecture 1

Thursday, June 17, 2021 11:00 AM (2 hours)

Gravitational Waves (GWs) represent a unique tool to explore the physics and the microphysics of the universe. After the GW direct detections by the LIGO/Virgo collaboration, the next target of modern cosmology is the detection of Stochastic Gravitational Wave Backgrounds (SGWB), both of cosmological and astrophysical origin. In this lectures, I will present early universe scenarios that can be probed with future GW detectors; in particular I will show how the LISA and Einstein Telescope (ET) interferometers, in addition to the detection and characterization of GWs of astrophysical origin, will give compelling information about the cosmological background of GWs. I will discuss the main tools and observables to deal with GW physics at interferometers.

Primary author: RICCIARDONE, Angelo (Padua U., INFN)

Presenter: RICCIARDONE, Angelo (Padua U., INFN)

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

Primordial gravitational waves and interferometers - Lecture 2

Friday, June 18, 2021 11:00 AM (2 hours)

Gravitational Waves (GWs) represent a unique tool to explore the physics and the microphysics of the universe. After the GW direct detections by the LIGO/Virgo collaboration, the next target of modern cosmology is the detection of Stochastic Gravitational Wave Backgrounds (SGWB), both of cosmological and astrophysical origin. In this lectures, I will present early universe scenarios that can be probed with future GW detectors; in particular I will show how the LISA and Einstein Telescope (ET) interferometers, in addition to the detection and characterization of GWs of astrophysical origin, will give compelling information about the cosmological background of GWs. I will discuss the main tools and observables to deal with GW physics at interferometers.

Primary author: RICCIARDONE, Angelo (Padua U., INFN)

Presenter: RICCIARDONE, Angelo (Padua U., INFN)

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

Lattice QCD: a primer of methods and results - Lecture 1

Monday, June 28, 2021 11:00 AM (2 hours)

The lattice regularization of Quantum Field Theories is a first-principles approach that allows to explore their non-perturbative regime via computer simulations. Over the years, it has provided valuable inputs to experimental studies and has contributed to the understanding of some of the deepest features of strongly-interacting field theories. The constant improvement of algorithms and computational power makes the lattice regularization an essential tool in the hands of the theoretical physicists of the future. In these lectures, the theoretical foundations of this approach will be reviewed, and some of the main results and currently open problems will be discussed

Primary author: VADACCHINO, Davide (Trinity College, Dublin)

Presenter: VADACCHINO, Davide (Trinity College, Dublin)

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

Lattice QCD: a primer of methods and results - Lecture 2

Tuesday, June 29, 2021 11:00 AM (2 hours)

The lattice regularization of Quantum Field Theories is a first-principles approach that allows to explore their non-perturbative regime via computer simulations. Over the years, it has provided valuable inputs to experimental studies and has contributed to the understanding of some of the deepest features of strongly-interacting field theories. The constant improvement of algorithms and computational power makes the lattice regularization an essential tool in the hands of the theoretical physicists of the future. In these lectures, the theoretical foundations of this approach will be reviewed, and some of the main results and currently open problems will be discussed

Primary author: VADACCHINO, Davide (Trinity College, Dublin)

Presenter: VADACCHINO, Davide (Trinity College, Dublin)

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

Introduction on relativistic projection effects on cosmological scales - Lecture 1

Friday, December 10, 2021 10:00 AM (2 hours)

Upcoming surveys will probe increasingly large scales, approaching and even exceeding the Hubble scale at the survey redshifts. On these cosmological scales, surveys can in principle provide the best constraints on dark energy and modified gravity models –and will be able to test general relativity itself. In order to realise the potential of these surveys, we need to ensure that we are using a correct analysis, i.e. a general relativistic analysis, on cosmological scales. In the first part of this lecture I will make a general overview of my research related to these effects both for the galaxy clustering and for the GWs. Then I will analyse in detail the relativistic effects which alter the observed number over-density through projection onto our past light-cone. This gives the well-known corrections from redshift space distortions and gravitational lensing convergence, but there are further Doppler, Sachs-Wolfe, integrated SW and time-delay type terms.

Primary author: BERTACCA, Daniele (Dipartimento di Fisica e Astronomia ”Galileo Galilei” Universita’ degli Studi di Padova)

Presenter: BERTACCA, Daniele (Dipartimento di Fisica e Astronomia ”Galileo Galilei” Universita’ degli Studi di Padova)

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

The holographic approach to non-perturbative QCD and baryon physics - Lecture 1

Monday, September 13, 2021 10:00 AM (2 hours)

The Gauge/Gravity duality introduced a new tool for investigating QFTs in non perturbative regimes: the most phenomenologically relevant example of these theories is QCD at low energy (at the scale of nuclear physics), whose spectrum of bound states ranges from glueballs, to mesons, to complicated atomic nuclei. In these lectures we will review the Gauge/Gravity duality and discuss its extension to (almost) QCD, illustrating the top-down model of Witten-Sakai-Sugimoto: we will show the emergence of baryons from the model, and how to use it to compute observables that can prove themselves challenging via other techniques.

Primary author: BARTOLINI, Lorenzo (Henan University)

Presenter: BARTOLINI, Lorenzo (Henan University)

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

The holographic approach to non-perturbative QCD and baryon physics - Lecture 2

Tuesday, September 14, 2021 10:00 AM (2 hours)

The Gauge/Gravity duality introduced a new tool for investigating QFTs in non perturbative regimes: the most phenomenologically relevant example of these theories is QCD at low energy (at the scale of nuclear physics), whose spectrum of bound states ranges from glueballs, to mesons, to complicated atomic nuclei. In these lectures we will review the Gauge/Gravity duality and discuss its extension to (almost) QCD, illustrating the top-down model of Witten-Sakai-Sugimoto: we will show the emergence of baryons from the model, and how to use it to compute observables that can prove themselves challenging via other techniques.

Primary author: BARTOLINI, Lorenzo (Henan University)

Presenter: BARTOLINI, Lorenzo (Henan University)

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

Localization of supersymmetric gauge theories in three dimensions - Lecture 1

Thursday, April 29, 2021 11:00 AM (2 hours)

Supersymmetric Quantum Field Theories provide an exciting arena for exploring physics in the strong coupling regime. Supersymmetric localization has turned out to be a formidable tool for making progress in this direction. The goal of these lectures is to provide a concrete example of supersymmetric localization in the context of three-dimensional gauge theories. I will first review the basic idea of localization in the finite-dimensional case. I will then show an application of this idea to supersymmetric Chern-Simons matter theories. In particular, I will explain how matrix models capture the partition function of these theories.

Primary author: GUERRINI, Luigi (Università di Parma, INFN)

Presenter: GUERRINI, Luigi (Università di Parma, INFN)

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

Localization of supersymmetric gauge theories in three dimensions - Lecture 2

Friday, April 30, 2021 11:00 AM (2 hours)

Supersymmetric Quantum Field Theories provide an exciting arena for exploring physics in the strong coupling regime. Supersymmetric localization has turned out to be a formidable tool for making progress in this direction. The goal of these lectures is to provide a concrete example of supersymmetric localization in the context of three-dimensional gauge theories. I will first review the basic idea of localization in the finite-dimensional case. I will then show an application of this idea to supersymmetric Chern-Simons matter theories. In particular, I will explain how matrix models capture the partition function of these theories.

Primary author: GUERRINI, Luigi (Università di Parma, INFN)

Presenter: GUERRINI, Luigi (Università di Parma, INFN)

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

Solution generation techniques in gravitational theories - Lecture 1

Thursday, November 25, 2021 11:00 AM (2 hours)

The construction of exact solutions in gravitational theories, from black holes to cosmological solutions, is of great interest. In these lectures, we will give an overview of the solution generation techniques in the realm of gravitational theories by focusing on two of them: the Ernst formalism and the inverse scattering method. In both cases, we will explicitly construct the integration scheme for the equations of motion and we will apply it to some relevant examples of black hole physics.

Presenter: VIGANÒ, Adriano (INFN, Milan and Milan U.)

Contribution ID: **28** Type: **not specified**

Solution generation techniques in gravitational theories - Lecture 2

Friday, November 26, 2021 11:00 AM (2 hours)

The construction of exact solutions in gravitational theories, from black holes to cosmological solutions, is of great interest. In these lectures, we will give an overview of the solution generation techniques in the realm of gravitational theories by focusing on two of them: the Ernst formalism and the inverse scattering method. In both cases, we will explicitly construct the integration scheme for the equations of motion and we will apply it to some relevant examples of black hole physics.

Presenter: VIGANÒ, Adriano (INFN, Milan and Milan U.)

Contribution ID: **31** Type: **not specified**

Higher-derivative quantum field theories, unitarity and quantum gravity - Lecture 1

Thursday, October 14, 2021 10:00 AM (2 hours)

These lectures aim to clarify several aspects of higher-derivative quantum field theories, their issues and how to circumvent them. A special attention will be given to quantum gravity. After reviewing general definitions we discuss the role of higher derivatives in both effective field theories and fundamental ones. Focusing on the latter, we explore the class of theories suitable for quantum gravity, discuss their features and the issues with unitarity. Finally, we show how to reconcile renormalizability and unitarity by means of purely virtual quanta.

Presenter: PIVA, Marco (NICPB Tallinn)

Contribution ID: **32** Type: **not specified**

Higher-derivative quantum field theories, unitarity and quantum gravity - Lecture 2

Friday, October 15, 2021 10:00 AM (2 hours)

These lectures aim to clarify several aspects of higher-derivative quantum field theories, their issues and how to circumvent them. A special attention will be given to quantum gravity. After reviewing general definitions we discuss the role of higher derivatives in both effective field theories and fundamental ones. Focusing on the latter, we explore the class of theories suitable for quantum gravity, discuss their features and the issues with unitarity. Finally, we show how to reconcile renormalizability and unitarity by means of purely virtual quanta.

Presenter: PIVA, Marco (NICPB Tallinn)

Contribution ID: **33** Type: **not specified**

Bootstrapping Cosmological Fluctuations - Lecture 1

Monday, November 15, 2021 3:00 PM (2 hours)

Reconstructing the physics of the very early universe from current observations is one of the most exciting challenges of theoretical cosmology. The main objects of interest in this context are correlation functions of perturbations on the spatial slice sitting at the end of inflation. In these lectures I will review a new approach—the "cosmological bootstrap"—that attempts to derive these correlators without making reference to the inflationary time evolution. The aim is to directly fix them at the boundary where they reside by using symmetries and elementary physical principles. This new point of view is helping us bridge the gap between theory and observations and is providing new insights into the physics of inflation and de Sitter space.

Presenter: DUASO PUEYO, Carlos (University of Amsterdam)

Contribution ID: **35** Type: **not specified**

Bootstrapping Cosmological Fluctuations - Lecture 2

Tuesday, November 16, 2021 3:00 PM (2 hours)

Reconstructing the physics of the very early universe from current observations is one of the most exciting challenges of theoretical cosmology. The main objects of interest in this context are correlation functions of perturbations on the spatial slice sitting at the end of inflation. In these lectures I will review a new approach—the "cosmological bootstrap"—that attempts to derive these correlators without making reference to the inflationary time evolution. The aim is to directly fix them at the boundary where they reside by using symmetries and elementary physical principles. This new point of view is helping us bridge the gap between theory and observations and is providing new insights into the physics of inflation and de Sitter space.

Presenter: DUASO PUEYO, Carlos (University of Amsterdam)