2021 Summer School on Cosmology and Particle Physics (Online)

Monday, 16 August 2021 - Friday, 20 August 2021

CTPU PTC

Scientific Programme

**Supersymmetry and Duality (□□□) **

Supersymmetry has been a fascinating idea to pursue for a number of reasons - gauge hierarchy problem, grand unification, and so on. In this series of lectures, we take a different approach, namely using supersymmetry to control the highly quantum behavior of strongly-coupled field theory. We focus on understanding aspects of renormalization group (RG) flow with the help of supersymmetry. It provides not only a solid test ground to understand the most basic aspects of quantum field theory (QFT) but also reveals deeper aspects of QFT, namely the concept of duality.

Rough outline: (subject to change)

1. Introduction & Classical theory

2. Quantum: Perturbation theory

3. Abelian Gauge theory & Electric-Magnetic Duality

4. Non-abelian Gauge theory

5. RG flow and Seiberg duality

References: hep-th/0309149, hep-th/0505153, 1812.08946

(more canonical ones: Wess & Bagger, hep-th/9509066, https://homepages.uc.edu/~argyrepc/cu661-gr-SUSY/susy1996.pdf)

Note:

 - I will NOT cover superspace formalism nor supersymmetry algebra in detail. It would be beneficial for the students to read Wess & Bagger's book from chapters 1 to 8 in advance.

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- 초록 : 4개로 이루어진 본 강의는 입자물리의 현상론을 연구하기위해 필요한 양자장론을 기반으로 하는 기본적인 이론적인 개념 및 도구들을 소개하고,

입자물리의 주요 안건을 다룰 간력하게 다룰 것이다.

1. The Standard Model of Particle Physics 1

2. The Standard Model of Particle Physics 2

3. Effective Field Theory 1

4. Effective Field Theory 2

5. CFT for phenomenology

GW and particle cosmology (정성훈)

Lecture 1. Preliminaries: Cosmology

Lecture 2. GW from black hole mergers

Lecture 3. GW from phase transitions

Lecture 4. GW from inflation

Lecture 5. Quantum evolution: Hubble selection

Advanced general relativity (박미옥)

1. Description of hypersurface : basic concept, Gauss-Codazzi equation, Junction condition

2. Lagrangian formulation of general relativity : Gibbons-Hawking term, non-dynamical term

3. Application (if time allows)

Brief introduction to cosmology and large scale structure (Jiajun Zhang)

This lecture will be separated into two parts, lesson and practice, lasting 3 hours in total. I will briefly introduce the key points in modern cosmology and large scale structure of the universe in the lesson for about 1.5 hours. Then I will provide a guide to widely used python packages and software in cosmology. The students shall bring their laptop and install a python environment before this lecture. In the practice lecture, I will give several different python coding work for the students to do, for about 1.5 hours.

Glimpses of new physics through neutrinos (Mehedi Masud)

Abstract: After the discovery of neutrino oscillation around twenty years back, the focus is now on various fundamental pressing issues, - such as, the search for leptonic CP-Violation, determination of the ordering of neutrino masses and the precision measurement of the oscillation parameters. The answers to these questions will help in uncovering more fundamental mysteries, such as why there is more matter than antimatter in the observed universe or whether neutrinos are their own antiparticle. Several powerful, high-precision neutrino experiments are in the pipeline to address these issues and these mega-facilities are also sensitive to new Beyond the Standard Model (BSM) physics. In this talk, I will give a brief description about where we are currently standing with the research in neutrino oscillation and how we can probe different BSM physics such as Non-Standard Interaction (NSI) during neutrino propagation, existence of a light sterile neutrino, presence of Lorentz Invariance Violation (LIV) etc.

Title: Extra dimensions and their compactifications (Pablo Soler Gomis)

Abstract: Extra dimensions are one of the most common extensions of the Standard Model of particle physics, particularly prominent in models arising from string theory. I will present in this lecture some elementary aspects of extra dimensions and their compactifications: Kaluza-Klein theory, warped extra dimensions, supersymmetry, etc.