

Extra-dimensions: Kaluza-Klein theories and Randall-Sundrum models

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Abstract

The Standard Model of particle physics is one of the most tested theory in physics. Recently, with the discovery at LHC of a particle with a mass of 125GeV that can be identified with the missing Higgs boson, it received a major experimental confirmation. Despite the great success of the Standard Model it is believed that it is an effective theory of a more fundamental theory, since there are many points which cannot be explained within this model. Several theories extending the Standard Model exist but only partially solve some of its problems. In these lectures we will focus on one possible extension of the Standard Model where it is assumed that the number of space-time dimensions is higher than four.

The first part of the lectures will be devoted to a brief introduction to General Relativity and to the Standard Model of Particle Physics. General Relativity is the theory of (Relativistic) gravitational interactions and allows for the description the Universe. As to the Standard Model, it is a (Quantum) description of the fundamental interactions: electromagnetism, weak and strong, and it is central in the description of Particles Physics.¹

The second part of these lectures is dedicated to a study of Kaluza-Klein theories. In such theories the structure of the space-time is the usual four-dimensional space-time with an additional compact (*i.e.* very small, that is with typical dimensions of the order of the Planck length $\sim 10^{-33}cm$) space. We will show how electromagnetism and gravitation can be unified in a five dimensional space-time. Then, considering space-times of dimension higher than five we will discuss how the other interactions can be included.

In the third part of these lectures we will focus on Randall-Sundrum models. The key observation of these models is the fact that gravitation was not tested for distances of the order of the mm allowing for large extra-dimensions. We will then study the so-called Randall-Sundrum models where a large extra-dimension is considered leading to brane-cosmology. These models provide an alternative solution of the hierarchy problem associated to the Higgs boson different from Supersymmetry. We show how the Standard Model can be incorporated in these models, where the particles of the Standard Model are restricted to a four dimensional space-time (a three-brane) and the gravitation is living in the five dimensional space-time (the bulk).

We will conclude by some phenomenological considerations.

The lectures will take place at IPHC, 23 rue du Loess, 67037 Strasbourg from 16:00 to 18:00 in

Amphi Grunwald, Bât 25: 17, 19, 24, 26, 31 March and 2, 7, 9 April.

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¹We will not study the problem of symmetry breaking associated to the Higgs boson since it will be the subject of the lecture of Nouredine MOHAMMEDI at the Doctoral School.