

HEPI

THEORETICAL INVESTIGATIONS

I. SPIN PHYSICS (Theory)

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1) Deep – Inelastic Processes and Polarization Phenomena

Subject of investigation:

Recent progress in increasing precision of experimental data at leading world's experimental facilities has resulted in clear understanding of the need for the next-to-next-to-leading order (NNLO) results in modern high-energy physics phenomenology. This needs to develop methods of quantum field theory to calculate cross sections.

At the leading order (LO) Born term level and the next-to-leading order (NLO), various heavy quark production mechanisms have been studied some time ago. But it isn't enough.

Results:

- a) We consider the production of heavy-quark pairs in the collisions of polarized and unpolarized on-shell photons and present, in analytic form, the fully integrated total cross sections for total photon spins $J_z = 0, \pm 2$ at next-to-leading-order in QCD.
- b) We calculate the next-to-next-to-leading order $O(\alpha^4)$ one-loop squared corrections to the production of heavy quark pairs in quark-antiquark annihilations. Our results, are presented in a closed and very compact form, in the dimensional regularization scheme.
- c) We have found factorization properties for the finite part of the amplitudes.

2) **Dynamical symmetry**

Subject of investigation:

Investigation dynamical symmetries of Dirac equation in $N = 2$ Witten superalgebra point of view and the additional hidden symmetry of the Coulomb-Kepler problem in classical as well as in quantum mechanics.

Results:

- a) They are hidden symmetries in the Dirac equation, where it is shown that the requirement of invariance of the Dirac Hamiltonian under some kind of Witten's superalgebra, picks out the Coulomb potential only.
- b) The problem in the arbitrary higher dimensions is also considered. It is derived that the traditional view on the Coulomb potential is to be changed in the context of $N=2$ supersymmetry.

3) **Self-adjoint extension problem in quantum mechanics**

Subject of investigation: For singular potentials self – adjoint extension is necessary, because isn't enough to demand Hermiticity of operator. Problem of dependence of physical quantities characterizing bound states and scattering processes on the self – adjoint parameter for singular potentials in the Schrodinger and various relativistic equations

Results

- a) For singular potentials self – adjoint extension procedure is performed in Schrodinger and various relativistic equations
- b) Is obtained dependence of physical quantities on the self – adjoint parameter
- c) Is modified Virial and Feynman-Hellmann theorems for singular potentials
- d) Is established status of Radial Schrodinger equation

II. The Three-Body Problem in an Elementary Particle Physics

Participants: Teimuraz Kopaleishvili, Tamar Babutsidze,
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Study of Bound qqq-Systems (Baryons)

Subject of investigation: The three-quarks systems ($N, \Sigma, \Lambda, \Xi, \Delta, \Omega$ baryons), their mass spectrum, form-factors and decays.

Methodology of investigation: The three-dimensional Lorentz-invariant Salpeter equation

Difficulties:

First. In a framework of QCD there is no clear possibility to construct a Salpeter equation kernel. This kernel is quarks interaction (confinement) and is select “by hands”.

Second. The solution of three-body problem taking into account relativity presents great analytical and numerical difficulties.

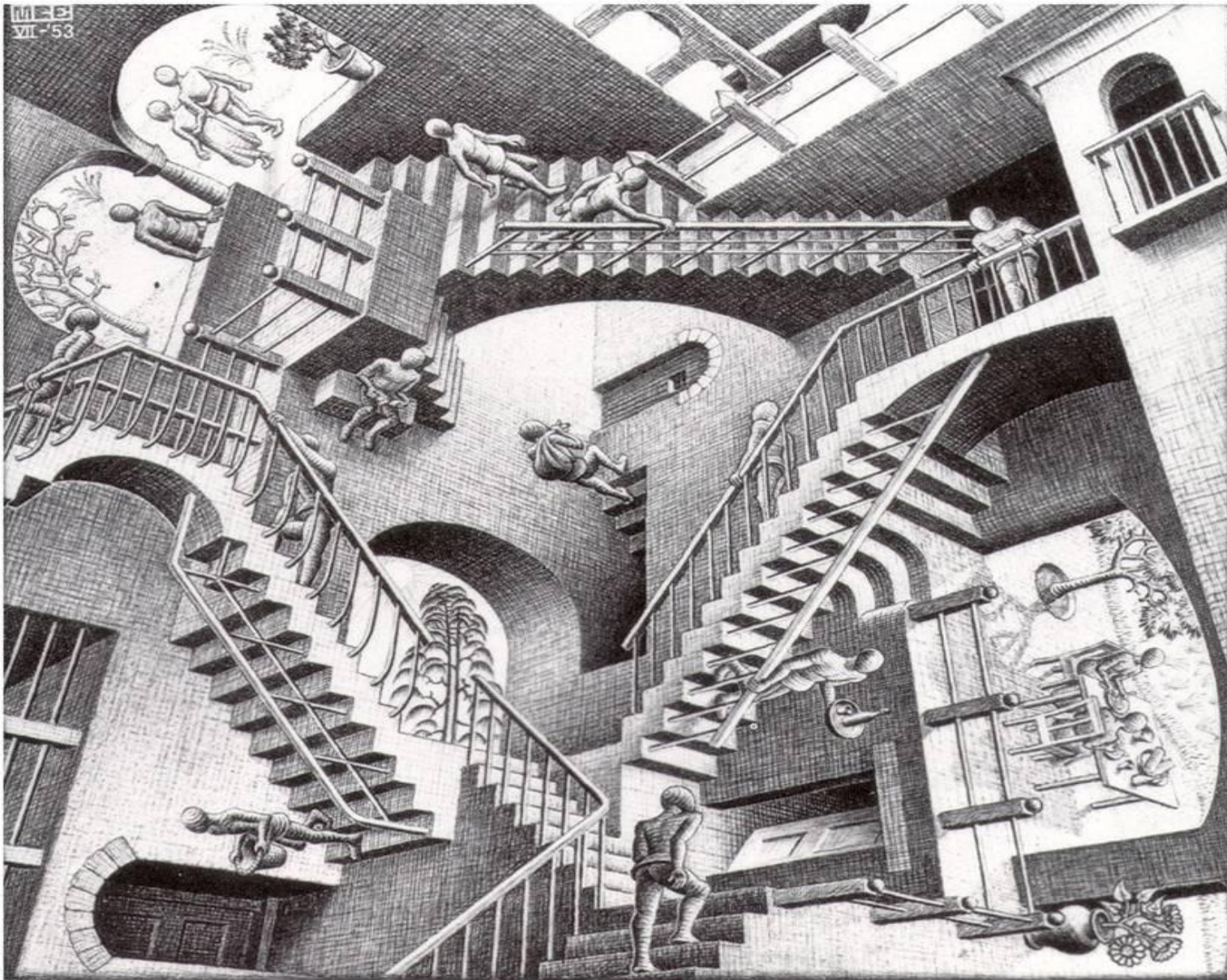
Results:

- a) 64- component spinor from a Salpeter equation taking into account a stability conditions is reduce to two 8- component spinors.
- b) For these spinors construction rules are established. The system of equations for these spinors is obtained.
- c) The matrix elements including into this system are calculated. In these calculations are used 3-particle

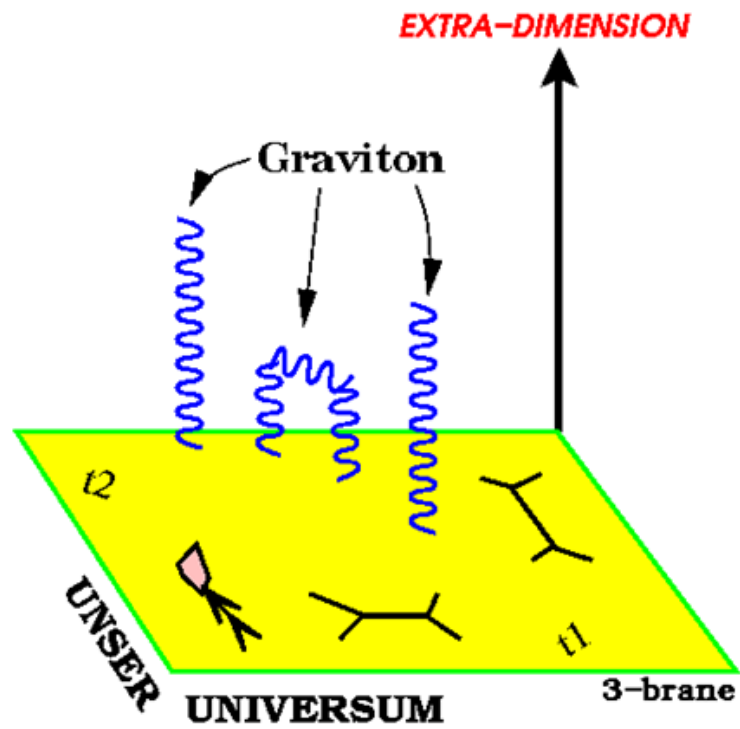
K-harmonics and depending on a collective variable
oscillatory functions.

II. Phenomenology of Large Extra Dimensions in the Flavor Physics

Participants: Akaki Liparteliani and Gela Devidze



TWON



Subject of investigation:

The aim of theoretical investigations is to find trace of extra dimensions in radiation decays of B mesons and charged leptons.

Results:

The main result of theoretical considerations is that, the trace of extra dimensions may be observed only at very small distances, reachable in Large Hadron Collider – LHC (ATLAS) and LHC(b) and more detailed investigation is possible at B mesons SuperB fabric in Frascati (Italy) or at KEK(Japan) accelerator.