

【Grant-in-Aid for Scientific Research(S)】

Science and Engineering (Mathematical and physical sciences)



Title of Project : Symmetry Breakings and the Gauge Dynamics

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Research Area : Mathematical and physical sciences, Physics, Particle/Nuclear/Cosmic ray/Astro physics

Keyword : Particle physics (theory)

【Purpose and Background of the Research】

Symmetry and symmetry breaking are the most fundamental concepts in modern particle theory. In the Standard Model gauge symmetry is essential and the mass of all the particles is generated by the spontaneous symmetry breaking. The Kobayashi-Maskawa theory for CP symmetry breaking also presumes nonzero quark mass and is deeply tied with the origin of mass. Thus the origin of mass and symmetry breaking is the most urgent problem of the particle physics today and as such is the main target of the LHC experiments.

In this project we will pursue breaking of various symmetries in particle physics and its dynamical origin via gauge dynamics with particular emphasis on the relation to the origin of mass.

The PI has been persistently studying the nonlinear realization of symmetry, the effective theory of the spontaneously broken system, which was further advanced by Yamawaki (CO-I) as the "Hidden Local Symmetry (HLS)" theory.

Symmetry breaking due to underlying gauge dynamics was first revealed by the PI and was further developed by Yamawaki into the 'Walking Technicolor' which has conformal (scale-) symmetry, with the coupling strength being almost independent of the scale, i.e., non-running ('walking'), for wide energy scale.

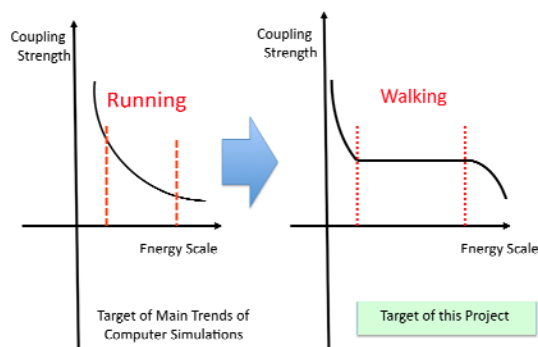


Fig. 1 Walking Technicolor

We will study such a gauge dynamics not only analytically but also numerically by computer simulations using a new high performance cluster computer at Kobayashi-Maskawa Institute for the Origin of Particles and the

Universe, Nagoya University, aiming at a breakthrough into new physics beyond the Standard Model.

【Research Methods】

We will study various symmetry breakings to study model buildings beyond the Standard Model. Relevant gauge dynamics includes near conformal dynamics such as the 'large Nf QCD' which will be studied by computer simulations based on the lattice gauge theories. This will be matched with 'chiral perturbation theory' based on the nonlinear realization (including HLS). The model buildings based on the results will be tested by the LHC collider experiments.

【Expected Research Achievements and Scientific Significance】

As it is symbolized by 2008 Nobel prize, study of symmetry breakings has been led by Japanese originality. PI also initiated research of the origin of mass based on the gauge dynamics. Combined with the computer simulations, we shall make quantitative as well as qualitative studies of the conformal gauge dynamics as a model beyond the Standard Model, which should be tested by the LHC experiments. In contrast to the conventional computer simulations of QCD, our target is the conformal gauge dynamics created by us and should be leading the world in the LHC era.

【Publications Relevant to the Project】

- M.Maskawa and H.Nakajima, "Spontaneous Symmetry Breaking in Vector-Gluon Model", Progress of Theoretical Physics, Vol.52, 1326-1354 (1974)
- K.Yamawaki, M.Bando and K.Matsumoto "Scale-Invariant Hypercolor Model and Dilaton", Physical Review Letters, Vol.56, 1335-1338(1986)

【Term of Project】 FY2010-2014

【Budget Allocation】 165,900 Thousand Yen

【Homepage Address and Other Contact Information】

<http://www.kmi.nagoya-u.ac.jp/>