Past Research

I study the Yang-Mills theory with or without gravitational interaction in higher dimensional space-time, whose dimensions are greater than 4. This is motivated by superstring theory, which is a trial of unification of interactions in the realm of nature.

There are many papers on the superstring theory in the critical dimension, 10. Though the definition of the string interaction has been attempted for long years, there is no enough definition.

The research on the reduced matrix models is a trial to define string interaction including non-perturbative effects. I study the Itoyama-Tokura model, which is such a model. In order to clarify the behavior of the fermion in the model, Itoyama and Matsuo analyze the Berry's phase as the fermion integral. Bin Chen, Hiroshi Itoyama, and I applied their method with the consideration of degeneracy and obtained non-Abelian Berry's phases. The Berry's phases are obtained by the path ordered exponential of the gauge field configurations against Yang monopole and generalized Wu-Yang monopole, which are five- and nine-dimensional monopoles respectively. These phases include geometrical information of the background of the model. The Yang monopole exhibits objects which extend along four dimensions spatially. We expect that the object is the seeds of our universe. (Mod. Phys. Lett. A14 (1999),Nucl. Phys. B577 (2000))

Hiroshi Itoyama, Reiji Yoshioka and I studied the topological aspect of the model from the point of view of matrix integral. We evaluated the Yang-Mills matrix integral of classical Lie groups, whose integrands are obtained by the dimensional reduction of the supersymmetric Yang-Mills action to zero dimensions, by using the Moore-Nekrasov-Shatashvili's method. (Nucl.Phys. B762 (2007))

Yang monopole is singular. Tchrakian considered a five-dimensional monopole with finite energy. Yutaka Hosotani, Muneto Nitta and I solved the Tchrakian's monopole differential equation numerically, in order to enrich our knowledge on the five-dimensional monopole and to regularize the Yang monopole. I derived differential equations of the higher dimensional Tchrakian's monopoles, and I suggested new series of models for higher dimensional monopoles. I showed the multi charged Thcrakian's five-dimensional monopoles. (Phys. Rev. D71:(2005),Phys. Rev. D 77 (2008), Phys.Rev.D79(2009), arXiv:0910.4425(2009))

Inspired by the research on the higher dimensional monopoles, Muneto Nitta and I studied the higher dimensional instantons, which are solutions of the generalized self-dual equations named by Tchrakian. The Hedge-Hog gauge configuration solves those equations. (Phys. Rev. D 77 (2008), Phys.Rev. D76 (2007), J.Math.Phys.50(2009)

The most important problem of the superstring theory is the explanation of the reason why our four-dimensional space-time appears from the ten-dimensional theory. One of the candidates is the compactification. Muneto Nitta, Misao Sasaki, Chul-Moon Yoo, Ignacio Zaballa and I solved the equation of motion of the ten-dimensional gravitational Yang-Mills theory with higher derivative coupling, putting the six-dimensional instanton solutions on six-dimensional sphere. The solution explains the dynamical compactification from ten to four and inflation.

Pravabati Chingangbam, Muneto Nitta and I showed that the gauge symmetry breaking is occurred against the solution. (Phys.Rev.D80(2009),Phys.Rev.D81(2010)) By embedding this solution into SO(16) gauge theory, the gauge symmetry is broken to SO(10). (arXiv:1004.2113(2010)) The Tchrakian's equations and their extensions are comparison between the Hodge dual of monomials of field strength and monomials. The generalization of the self-duality equation in the case of polynomial is done and exact solutions on $S^2 \times S^2 \times S^2$ and $S^2 \times S^4$ are exhibited. (arXiv:1103.0388(2011))