Research interests

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Past research

My research is mainly concerned with topological effects in reduced (i.e. zero dimensional) matrix models and the topological solitons in gauge theories. I would like to study the nonperturbative behavior of string theory for understanding a mechanism of the compactification, the origin of matter generations and unification of interactions.

My research area consists of two parts, Spherically symmetric soliton in six dimensional gauge theory and Non-Abelian Berry phase in reduced matrix models.

Spherically symmetric soliton in six dimensional gauge theory

This research is devoted to understanding finite energy solitons in higher dimensional spacetime which may be applicable to the brane world scenario. A spherically symmetric monopole solution (particle soliton) is found in SO(5) gauge theory with Higgs scalar fields in the vector representation in six-dimensional spacetime. The action of the Yang-Mills fields is quartic in field strengths. The Hamiltonian for this model is positive semi-definite. The solution saturates the Bogomolny bound by the topological charge taking a value in the fourth homotopy group of the coset constructed by broken symmetry and it is stable.

These classes of solutions are pointed out early, and there are some papers about the topological aspects of the classes. We found a model which include an explicit solution. The solution is regarded as magnetic source for three form abelian gauge field asymptotically. This situation is similar to M5 branes which are magnetic sources for three form gauge fields coupled with M2 branes in M theory.

This work is also motivated by my second research area described bellow.

Non-Abelian Berry phase in reduced matrix models

I would like to understand the topological effects of fermions in reduced matrix models, which are dimensional reduced models of super Yang-Mills theories from ten dimension to zero dimension. They are expected to include nonperturbative effects of strings and to define interaction among strings. We found that a model dual to a reduced matrix model including open string sector contains 4-branes and orientifolds. We suggest that these objects are sources of the structure of our universe. We expect that our universe is realized on these 4-branes which may be piled up. This work pushes a renewed understanding of old notions such as compactification and spacetime distribution.

In the two papers the effective actions coming from fermionic matrix integrals on the background where bosonic matrices are diagonal are discussed. These diagonal factors of bosonic matrices are considerd as spacetime points. We showed that four branes, orientifolds and zero branes appear depending on the representations of fermions. We calculated these phases in the two models, the Ishibashi-Kawai-Kitazawa-Tsuchiya (IKKT) model and the Itoyama-Tokura (IT) model. The effective actions in IT model include phase factors as path ordered exponentials of su(2) anti-selfdual connections, which are the Belavin-Polyakov-Schwartz-Tyupkin instantons on four dimensional spheres enclosed points in five dimensional space. They have singularities on the centers of the spheres. These connections are invariant under translations with four directions and the four dimensional planes which consist of their singularities appear. The planes are regarded as "seeds" of our universe. These planes look like four branes and orientifold four planes. We obtained another phases which appear particle like objects in ten dimension.

We thus found the IT model including open string contains 0-branes, 4-branes and orientifolds.