Our Team

Mikhail Kapranov

Research Field: Mathematics

Professor

My research is in the areas of algebra, algebraic geometry and category theory. These areas are the source of powerful conceptual tools for understanding the concept of space in a wide sense, from very classical to very abstract.

For example, the classical subject of hypergeometric functions was developed (in my joint works with I.M. Gelfand and A.V. Zelevinsky) to include period integrals of algebraic hypersurfaces in toric varieties. This led us to the discovery of secondary polytopes, which are combinatorial geometric objects governing both hypergeometric functions and discriminant polynomials in singularity theory. These concepts are now widely used in Mirror Symmetry.

Other directions of algebraic geometry which I am interested in (and have worked) include non-commutative geometry (study of the neighborhood of the commutative regime), derived and infinite-dimensional geometry (algebro-geometric study of spaces of formal loops and paths).

Category theory provides a unified background for all these areas. In addition, various flavors of category theory (triangulated categories, higher categories, theory of operads) lead to contexts where algebraic expressions themselves become objects with non-trivial geometric structure, not really expressible on a (1-dimensional) line. This additional interface of algebra and geometry seems necessary in order to approach truly higher-dimensional problems.

Shamik Banerjee

Research Field: Theoretical Physics

Postdoc

My main research interest is string theory and field theory. My recent work focuses on entanglement entropy. Entanglement entropy has applications in many branches of physics starting from black holes to quantum critical phenomena. It is also an emerging tool in field theory. I am trying to develop new non-perturbative techniques for calculating entanglement entropy in field theory. I am also interested in holographic, or, more precisely, AdS-CFT duality. It gives us a host of exact results for entanglement entropy, and one of the motivations for developing new techniques is to explain these results from the field theory side.

Christophe Bronner

Research Field: Experimental Physics

Postdoc

My research focuses on the experimental study of neutrinos, and more particularly on the phenomenon of neutrino oscillations, where a neutrino produced in a given flavor can be later observed to interact as a neutrino of another flavor. This phenomenon could also violate CP symmetry, in which case neutrinos and anti-neutrinos would oscillate differently.

Most of my work has been done in the Tokai to Kamioka (T2K) experiment, in which a beam of muon neutrinos is produced in the J-PARC center on the East coast of Japan and sent to the Super-Kamiokande detector in the Gifu prefecture to study neutrino oscillations. I have been working on the near detectors construction and operation, as well as on analysis of T2K data to measure some of the parameters of the PMNS model, describing neutrino oscillations.

Yohsuke Imagi

Research Field: Mathematics

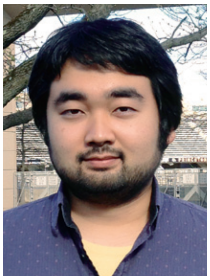
Postdoc

I am studying special Lagrangian geometry, an area of differential geometry. For Yang-Mills instantons in dimension 4 and pseudo-holomorphic curves, we already have a good understanding of singularities, and we can define a nice compactification of moduli spaces, which is a source of interesting mathematics and physics. One may want to do something similar for special Lagrangian submanifolds, but their singularities seem considerably more difficult to analyze than those of Yang-Mills instantons in dimension 4, or those of pseudo-holomorphic curves. So we have not yet achieved a "nice" compactification of the moduli space of special Lagrangian submanifolds. I am developing a deep theory on "simple" singularities, using some techniques from geometric measure theory and Lagrangian Floer theory.

Hironao Miyatake

Research Field: Cosmology

Postdoc



I am interested in what the acceleration of the Universe indicates in the context of fundamental physics. I have been working on reconstructing the distribution of dark matter by analyzing the weak lensing effect on imaging data. What I would like to accomplish at the Kavli IPMU is to measure the matter distribution of an even larger volume through data taken by the Hyper Suprime-Cam Survey that started from March 2014, and to constrain the nature of dark energy and test gravity theory based on this mass distribution.

Koichi Nagasaki

Research Field: Theoretical Physics

Postdoc

I was working on string theory and supersymmetric field theories. Now I am interested in the AdS/CFT correspondence which is thought to be a useful tool for studying unknown properties of string theory. Recently I was studying a certain class of operators called non-local operators. I proposed their gravity duals and showed complete agreement between gauge and gravity theories.

Recently, I am considering a system consisting of D3 branes and probe D-branes. This system gives a special gauge theory which contains defects or boundaries. Using this system, I am thinking of revealing relations between these non-local operators and brane configurations.

Natsumi Nagata

Research Field: Theoretical Physics

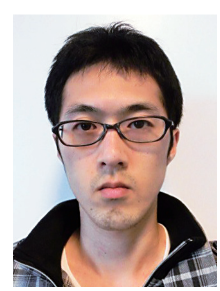
Postdoc

My current research interest is to study the physical observables which are sensitive to physics beyond the Standard Model. In particular, I have been focusing on the direct searches of dark matter, the measurements of the electric dipole moments, and the proton decay experiments, and developed the method of evaluating the contribution of new physics to the corresponding physical quantities. Such an approach based on the precision measurements can be complementary to the collider searches, and in fact the most promising when the scale of new physics, such as supersymmetry, is somewhat higher than the electroweak scale, as is suggested by the null result at the early stage of the LHC running.

Rio Saitou

Research Field: Cosmology

Postdoc

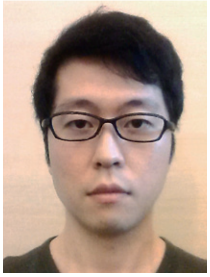


I aim to reveal the whole cosmic history from the beginning to the present day or the future. People believe that in the early universe, the universe had experienced the accelerated expansion called inflation, and the present universe is also accelerated by dark energy. We must make these phenomena clear. With this in mind, I investigated the models which unify the inflation and late-time acceleration. Now, I'm interested in the details of the gravitational wave created during inflation and the effect of the vacuum expectation value of the Higgs particle on the evolution of the universe.

Hiroshi Takano

Research Field: Theoretical Physics

Postdoc



I am studying about the phenomenology of neutrino and dark matter. These problems can be explained in TeV energy scale new physics, which is accessible by experiments in the near future. Recently, I am interested in the production scenarios of dark matter particles, thermal or non-thermal relics, cold or warm, and so on. I am trying to understand these scenarios and their general behavior.

Yasuhiro Takemoto

Research Field: Experimental Physics

Postdoc

How has this universe been formed? Neutrinos, one of the elemental particles, are an important probe for this question. Due to their extremely small cross section, neutrinos have provided us with direct information inside the sun or the earth. The possibility that neutrinos are Majorana particles further gives clear explanation of the current matter-dominant universe. I have been studying the universe using neutrinos in the KamLAND and KamLAND-Zen experiments. At the Kavli IPMU, I will continue this research and also I will start dark matter search using KamLAND.

Alexey Tolstov

Research Field: Astrophysics

Postdoc

The key issue around which my research interests are constructed is a question of understanding the mechanisms of supernova explosion and the origin of gamma-ray bursts based on the analysis of observational data: spectra and light curves. Numerical modeling of non-equilibrium radiative and hydrodynamic processes in expanding supernova envelopes provides me the ability to study nucleosynthesis signatures in the optical light curves and spectra of faint supernovae, the origin of extremely metal poor stars, and supernova shock breakout phenomenon for mildly relativistic ejecta. All of this helps to answer on some pressing questions of stellar evolution and cosmology.