Our Team

Simeon Hellerman

Research Area: Theoretical Physics

IPMU Associate Professor

I study the dynamics of gravity in situations where the short-distance structure of space-time becomes important, for example, in the early Universe. As a tool, I use string theory, which is the unique dynamical system incorporating both the existence of gravity and the uncertainty principle of quantum mechanics.

My recent work has mapped out the various different phases of string theory and the transitions the theory can make from one phase to another, in a cosmological environment. These phase transitions alter several features of the theory dramatically. For instance, the number of dimensions of the space-time can change, or the transition may restore a highly stable type of order known as supersymmetry, or else the character of the string dynamics may change altogether.

This network of connections has turned out to unify all known string theories for the first time — via dynamics that are intrinsically cosmological.

Tadashi Takayanagi

Research Area: Theoretical Physics

IPMU Associate Professor

Quantum mechanics describes microscopic physics, while physics at large scale is governed by general relativity. The unification of these two theories, called quantum gravity, is expected to reveal the origin of our universe and is obviously an ultimate goal of theoretical physics. Superstring theory is known as the most promising candidate to achieve this goal. Therefore I am exploring new predictions of quantum gravity arising from superstring theory.

Specifically, we constructed the first exactly solvable and dynamical model of quantum gravity that is completely stable. Even though its spacetime is two-dimensional and looks like a toy model, at present this is virtually the only string theory where we can compute everything exactly. In this model, called a type 0 matrix model, we can deal with multiple universes at the same time and consider quantum mechanical mixing between them.

I am currently interested in applying to quantum gravity the idea of entanglement entropy, which is an important component of quantum information theory. This offers us a new microscopic understanding of the Bekenstein-Hawking entropy of black holes. We have also developed a differential geometry interpretation of quantum information theory.

Naoki Yoshida

Research Area: Astrophysics

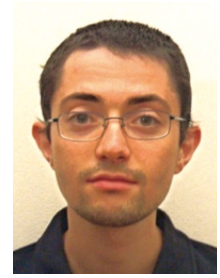
IPMU Associate Professor

I have been working on a broad range of topics in cosmology and astrophysics. I primarily use large computer simulations. Recent highlights of my work include simulations of star formation in the universe and statistical analyses of large-scale galaxy distributions. The former is for observations using next generation space-telescopes, which are expected to explore the distant universe. The latter study is aimed at optimizing dark energy surveys. At IPMU, I'd like to interact with many people to work on the important questions regarding the nature of dark matter and dark energy. Cosmology is now at a stage where theory can provide accurate and solid predictions, and observations can verify them. I am excited to work in this active research area.

Cosimo Bambi

Research Area: Theoretical Physics

Postdoc



Broadly speaking, my research interests include physics of the early Universe, tests of General Relativity and possible connections between gravity and particle physics.

At present I am very interested in the issue of the end state of the gravitational collapse of matter. In the framework of General Relativity and under apparently reasonable assumptions, we should expect the formation of a black hole. However, from a strictly theoretical point of view, black holes are a challenge, demanding new physics, while astrophysical observations cannot yet confirm unambiguously their existence.

Damien Easson

Research Area: Theoretical Physics

Postdoc

My research interests include topics at the interface of particle physics and cosmology. I am searching for answers to fundamental questions about the origins of the Universe, drawing on discoveries in quantum gravity and superstring theory. I am particularly interested in finding evidence of new physics in cosmological data from the cosmic microwave background radiation and large scale structure observations. Current research projects include: inflationary model building, discovering the nature of dark energy, modified gravity and the accelerating Universe, implications of extra dimensions of space, dark matter and quantum aspects of black holes.

Wei Li

Research Area: Theoretical Physics

Postdoc

My research focuses on string theory, especially the quantum gravity aspects of string theory. Apart from the big bang singularity, the black hole is the object where the tension between gravity and quantum physics is the strongest, hence it provides the best stage to test and unlock the full power of string theory. Therefore I am particularly interested in how to understand black holes microscopically using string theory. Recently I have also been working on a toy model of three-dimensional quantum gravities, with the hope of gaining some insight towards higher-dimensional quantum gravities.

Takaya Nozawa

Research Area: Astronomy

Postdoc

I am working on the evolution of dust in the early universe. Because dust grains absorb stellar light and re-emit it by thermal radiation, the existence of dust can play crucial roles in revealing the evolution of the universe from observations. So far I have determined the composition, size distribution, and amount of dust formed in primordial supernovae, as well as the destruction efficiency of dust in shocked hot gas. Currently I am studying the chemical evolution of dust and its impact on the relevant observations.

Brian Powell

Research Area: Cosmology

Postdoc

My primary research interest is inflationary cosmology — both its observational consequences and its theoretical origins. I have explored the possibility of using parameterization-independent approaches to constraining the inflationary power spectrum with the latest CMB and LSS data. The flow formalism is an effective method for identifying scales on which the data places the weakest constraints on the spectrum. I am also interested in applying methods of Bayesian analysis to the inflaton potential directly, both for parameter estimation and model selection.

Kai Wang

Research Area: Theoretical Physics

Postdoc

The Standard Model has been extremely successful in explaining numerous experimental observations in the energy regime up to a few hundred GeV. There are, however, many hints encouraging us to go beyond the Standard Model. We still have to answer several fundamental questions such as how EW symmetry is broken and if there is a Higgs boson, why a fundamental scalar in the theory is naturally at EW scale, what the dark matter is made of, and why the neutrinos have such small masses. These questions motivate my research. With the LHC coming online soon, it will open great opportunities to explore physics at the TeV scale. My research has been focusing on LHC phenomenology, especially signatures from new physics beyond the Standard Model.