

Description for the General Public

This project is proposed to explore the theories beyond Einstein's general relativity, study the properties and behaviour of gravity at ultra-high and ultra-low energy scales in the cosmological context, as well as the possible connections to the new physics beyond standard model of particle physics.

Today, three fundamental forces, electromagnetic force, weak force and strong force are well understood and have many applications in the human world. However, the fourth one gravity is different. Gravity remains the most mysterious among the four fundamental forces in nature. Experimentally, we still do not know how gravity behaves at distances shorter than 0.01 mm or longer than galaxy cluster scale. Thus, it is natural to ask whether there is new physics at shorter or longer distances? While this question at short distances is relevant for quantum gravity and the origin of universe, the question at long distances might potentially address the mysteries of the universe, such as the dark energy and dark matter.

Cosmology provides us a unique arena where gravitation and quantum physics meet each other. It is also a unique probe of ultra-high energy physics beyond energies which can be achieved at colliders. In cosmology, there are many clues to the new physics. In the very early universe, the energy scale could be as high as the scale of grand unification scale. This is much larger than any energy we can expect to achieve with particle accelerators in the foreseeable future. It is therefore very stirring to ask what's the properties of gravity at this ultra-high energy scale, and what's the observational effect due to the modified theories of gravitation.

At another extreme scale, the dark energy, or cosmological constant problem is a long standing problem in theoretical physics, and has been taken more and more seriously since the discovery of the accelerated expansion of our universe. What's the mysterious energy speeding up the cosmic expansion? Why its energy density is so small? The cosmic accelerated expansion enigma is the one of most fundamental problem in the modern science. One promising approach to the late time cosmic acceleration enigma is to modify Einstein's general relativity. The new theory of gravity may naturally have the solution of accelerated expanding universe. New physics at such large scale will also affect the matter distribution in our universe. The investigation on the theoretical and experimental properties of gravity theories will help us testify or falsify Einstein gravity at cosmological scale.