

Special course

"General Relativity and Elements of Cosmology"

Professor V. Zakharov

Program:

General Relativity is the most elegant mathematical theory ever invented for the needs of theoretical physics. This theory includes only two fitting constants: the light speed and the gravitational constant. Nevertheless, this theory is very powerful and explains all or nearly all relevant observations.

The most fundamental of these is the expansion of the Universe and the existence of very unusual and remarkable objects - "black holes" of different types. Moreover, General Relativity is an adequate tool for describing the evolution of the Universe since the very beginning - the Big Bang.

The main point of General Relativity theory is the following: matter changes the flat empty Minkowsky space of special relativity to a curved pseudo-Euclidean Riemann space. The natural mathematical language of General Relativity is differential geometry, more exactly, tensor calculus on manifolds. On the surface of the Earth and even inside the Sun, space is almost flat. However, near a black hole space is really a curve and its properties are quite sophisticated.

This course will consist of three sections. In the first one I will teach the elements of differential geometry and tensor calculus. The derivation of the Einstein equation will be done in the end of this section. Then I will present the theory of black holes, both stationary and rotating. Finally, I will explain the cosmological solutions of the Einstein equation and discuss the present state of cosmology. The problem of hidden mass will be treated in detail.

Prerequisites: Math215, Math223, Math254; preferably Math 425B. Knowledge of Special Relativity is necessary.