Spring Semester 2005

MATH 488-588

General Relativity and Elements of Cosmology

COURSE INFORMATION

Instructor:	Vladimir Zakharov, Professor
Office:	Mathematics Building, Room 518
Phone:	621-4841
E-mail:	zakharov@math.arizona.edu
Webpage:	http://math.arizona.edu/~zakharov/

Syllabus

General Relativity is the most elegant mathematical theory ever invented for the needs of theoretical physics. This theory includes only two fitting constants: the speed of light 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 Riemann spaces. On the surface of the Earth and even inside the Sun, space is almost flat. However, near a black hole space is curved and its properties are quite sophisticated.

This course will consist of three sections. In the first one I will explain the elements of differential geometry and tensor calculus. The derivation of Einstein's equation will be done by 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. I will describe also gravitational waves and discuss remarkable exact solutions of the Einstein equations – the "gravitational solitons".

Recommended books:

1. "General Relativity" by Robert M. Wald
2. "Tensors, Differential Forms, and Variational Privciples" by David Lovelock and Hanno Rund"