The First Course Handout of Phy 660: General relativity and cosmology

The course **General relativity and cosmology** whose number is **PHY 660** is the first standard course on cosmology aimed for students who do not know general relativity. The course will start with an introduction to the basic concepts of general relativity and then introduce the Einstein's equation in presence of an ideal barotropic fluid. The energy-momentum tensor for ideal fluids will be introduced initially. The preliminary concepts of particle physics and our knowledge of the basic building blocks of the cosmos will be briefly discussed initially.

After showing the properties of the cosmological solution, the Friedmann-Lemaitre-Robertson-Walker (FLRW) spacetime, the course will focus on thermodynamics of an expanding universe. The concepts related to radiation domination and matter domination will be introduced next and based on these concepts the standard model of cosmology will be introduced. The points about neutrino decoupling and photon decoupling producing the cosmic neutrino background and cosmic radiation background will be discussed.

In the next part of the course the shortcomings of the standard cosmological model will be discussed and to address the difficulties the concept of cosmological theory of inflation will be introduced. How inflation tackles the problems of standard cosmological model will be discussed thoroughly. The concept of cosmological perturbation theory will be briefly discussed.

The issue about dark energy and the problems of late time universe will be discussed in the last part of the course. The observational and theoretical aspects of accelerating universe will be introduced. The role of dark matter will be discussed as a part of the problem of structure formation. Some brief introduction to dark energy and dark matter theory will be presented and finally the course will end with the present day model of cosmology (ΛCDM model).

The grading scheme is as follows:

1. If possible there will be a **ten** marks (20 minutes) quiz before the mid-semester exam.
2. The mid-semester exam will be of **eighty** marks (2 hour).
3. If possible there will be a **ten** marks (20 minutes) quiz before the end-semester exam.
4. The end-semester examination will be of **hundred** marks (3 hours).

If the quizzes are not held then the mid-sem and end-sem marks will be properly adjusted. There will be no preassigned cutoff for this course, the cutoff will depend upon the overall performance of the class. There will be no special marks for attendance, but the students have to attend the classes regularly as the topics discussed in the class will be useful to answer questions in the quiz and examinations.

For the benefit of the students I list some of the important books which they can follow to understand the class proceedings. The books are as follows

1. **The early universe** by Edward W. Kolb and Michael S. Turner.
2. **Modern cosmology** by Scott Dodelson.
3. **Principles of physical cosmology** by P. J. E. Peebles.

Except these books the students can see any other book on classical mechanics which covers the subjects initially discussed. In the class we will not be following any particular book. Regular homework sets will be given to the students. The students are strongly advised to do the homeworks and submit the answers to me. The homeworks will not be graded but doing them will help you to understand the grading policy of the course.

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