Indian Institute of Technology, Kanpur

Proposal for a New Course

1. Course No: A **600 level elective** number requested**.**
2. Course Title: **Cosmology**
3. No. of Lectures per week: 3 (L), Tutorial: 0 (T), Laboratory: 0 (P), Additional Hours [0-2]: 0 (A),

   Credits (3*L+2*T+P+A): 09 Duration of Course: Full Semester
4. Proposing Department/IDP: PHY.

   Other Departments/IDPs which may be interested in the proposed course:

   Other faculty members interested in teaching the course: Kaushik Bhattacharya, Nilay Kundu.
5. Proposing Instructor: Debtosh Chowdhury, Sabyasachi Chakraborty.
6. Course Description:

A) Objectives: Explore the fascinating realm of modern cosmology, delving into the study of the Universe's contents and evolution. Covering topics such as expanding spacetime, the early Universe's thermal history, including nucleosynthesis and the cosmic microwave background, and the inflationary model for cosmic structure origins, this course offers students a comprehensive overview of contemporary cosmology. Beginning with the foundational principles of general relativity, we will develop models of an expanding universe and examine its correlation with the Universe's contents. From there, we will journey through the Universe's evolution, from its fiery beginnings to the synthesis of light elements and the emergence of the cosmic microwave background. Finally, we will explore the evolution of cosmological structures, from the generation of density fluctuations during inflation to the formation of bound halos.

B) Contents:

S. No.	Broad Title	Topics	No. of Lectures
1	**Introduction**	Observing the Universe, The expanding universe, timeline of key events, homogeneity & isotropy, units in cosmology	**2**
2	**Hubble Law and Geometry of Space**	Cosmological redshift, the Hubble law, symmetries of the space, Friedmann-Lemaitre-Robertson-Walker metric, geodesic equation, distances	**4**
3	**Contents of the Universe**	Perfect fluids, Continuity equation, Friedmann equations, single component universe, multi-component universe, exact solutions	**6**
4	**The Hot Big Bang**	Early universe thermodynamics, thermal equilibrium, entropy in the universe, neutrinos in cosmology, decoupling of neutrinos, cosmic neutrino background, cosmic microwave background, Boltzmann equation, Big Bang nucleosynthesis, Baryogenesis	**10**
5	**Cosmological Inflation**	Problems with the Hot Big Bang, Horizon Problem, Flatness problem, superhorizon correlations, Inflationary solution, physics of inflation, scalar field dynamics, slow-roll inflation, an invitation to reheating	**8**
6	**Large Scale Structure of the Universe**	Newtonian perturbation theory, growth of matter perturbations, Jeans instability, Linear growth function, Transfer function, Power spectrum, Harrison-Zel'dovich spectrum, structure formation, spherical collapse, Press-Schechter theory	**10**
		Total number of lectures:	**40**

C) Pre-requisites: PHY 432/PHY 626, PHY 412.

D) Short summary for including in the Courses of Study Booklet: The Expanding Universe, Dynamics of Spacetime, Cosmological Solutions; The Hot Big Bang, Recombination, Big Bang Nucleosynthesis, Cosmic Neutrino background, Cosmic Microwave Background; Cosmological inflation, Structure Formation, Density Perturbations, Power Spectrum, Large Scale structure of the Universe.

7. Recommended books:

I. Cosmology, D. Baumann, Cambridge University Press.
II. Modern Cosmology, S. Dodelson & F. Schmidt, 2nd ed., Academic Press.
III. The Early Universe, E. W. Kolb and M. S. Turner, Westview Press.
IV. Cosmology, S. Weinberg, Cambridge University Press.

Dated: March 07, 2024.

Proposer: Debtosh Chowdhury. Satyaki Chakraborty

Dated: 8/3/24

DPGC Convener (PHY):_____

The course is approved / not approved

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Chairman, SPGC

Dated:_____