Proposal for a new course: Department of Physics

1. <u>Course number</u>: 6XX

2. <u>Course title</u>: Advanced Quantum Field Theory

3. <u>Number of Lectures per week</u>: 3 Lectures [Tutorial: 0, Laboratory: 0, Additional hours: 0]

4. <u>Credits</u>: 09

5. <u>Duration of course</u>: Full semester

6. <u>Proposing Department</u>: Physics

7. <u>Other departments which may be interested in the course</u>: Mathematics

8. <u>Other members interested in teaching the course</u>: Diptarka Das, Nilay Kundu, Joydeep Chakrabortty, Apratim Kaviraj, Sabyasachi Chakraborty, Debtosh Chowdhury, Dipankar Chakraborti.

9. <u>Proposing instructor</u>: Arjun Bagchi

10. <u>Objective of the course</u>: Quantum Field Theory (QFT) is one of the fundamental tools of modern physics with broad ranging applications in all of theoretical physics including condensed matter physics, particle physics, and other areas of high energy physics.

    This is designed to be a second course on the subject which will follow PHY685 – Introduction to Quantum Field Theory. This course would introduce the student to the methods of path integral quantization and will focus on the understanding of non-Abelian gauge theories which generalize electrodynamics and is mathematical framework for understanding the strong and weak nuclear forces.

    A major part of the course would deal with renormalization. Answers to various processes in QFT often turn out to be infinite. Regularization and renormalization are used to extract physical answers out of these infinites. This course will lay out these formal procedures and show how to renormalize various QFTs.

11. <u>Course outline</u>:

    - Introduction [2 lectures]

    - Quantization of constrained systems [4 lectures]
        - Classification of constraints
        - Dirac method of quantization

- Classical aspects of gauge theories [4 lectures]

- Functional methods [8 lectures]
    - Path integrals for quantum mechanics
    - Path integral quantization of scalar fields, fermions and electrodynamics

- Quantization of Yang-Mills theories [8 lectures]
    - Path integrals, Fadeev-Poppov ghosts.
    - BRST quantization.

- Renormalization [10 lectures]
    - Systematics of renormalization
    - Renormalization group

- Advanced topics [3 lectures]
    - Anomalies
    - A glimpse of Conformal Field Theory

12. Prerequisites: Quantum field theory (PHY681)

13. Short summary for including in the courses of Study Booklet: Quantum Field Theory (QFT) is one of the fundamental tools of modern physics with broad ranging applications in all of theoretical physics including condensed matter physics, particle physics, and other areas of high energy physics. This course would carry forward the ideas and methods of QFT introduced in PHY685 into advanced topics. The topics covered would be quantization of constrained systems, functional methods, path integral quantization for fields of various spin, classical and quantum aspects of Yang-Mills theories, Systematics of renormalization and renormalization group.

14. Recommended Books:

- M. Peskin and D. Schroeder: *An Introduction to Quantum Field Theory*
- S. Weinberg: *The Quantum Theory of Fields: Vol 1 and 2.*
- M. Scredniki: *Quantum Field Theory*
- L. Ryder: *Quantum Field Theory*
- A. Zee: *Quantum Field Theory in a Nutshell.*

Date: November 29, 2024.   **Proposer: Arjun Bagchi**

Date: ....   DPGC Convenor (PHY):

The course is approved / not approved

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Chairman, SPGC

Date: ....