Post-MSc IInd Semester Courses (2019-20)

A) Optional Theory Courses:–

- 'Astrophysics of Supernovae and Neutron Stars'
  Instructor: Prof. Debades Bandyopadhyay
- 'Particle Physics'
  Instructors: Profs. Ambar Ghoshal & Prakash Mathews
- 'General Relativity'
  Instructor: Prof. Kumar Gupta & Tutor: Dr. Soumya Chakrabarti
- 'Quantum Field Theory-II'
  Instructor: Prof. Arnab Kundu

– Student's can enroll for any three of them.

B) Project/Review topics offered:–

- Project-1: **Entanglement dynamics and quantum information propagation in physical systems** (Prof. Kumar S. Gupta)

  Abstract: Entanglement is one of the most important features of a quantum system. The related concept of entanglement entropy has found applications in a variety of areas, ranging from dynamical systems developed in the lab to quantum aspects of black hole physics. A related concept is encoded in the process of quantum information, which is often characterised by various correlation functions, including the recently popular out-of-time-ordered correlators. The dynamics of quantum information propagation is of fundamental importance both conceptually as well as from an applied point of view.

  In this review project, it is proposed that the ideas of quantum entanglement dynamics and quantum information propagation be studied in variety of physical systems, with both finite and infinite dimensional Hilbert spaces. In particular, the non-equilibrium regimes of various systems obtained under a quenche protocol would be analyzed and their relation to thermalization would be studied. Application of these ideas to simple laboratory based systems as well as to high energy processes including black hole physics and conformal field theories would be investigated. In this process, both analytical as well as numerical techniques would be utilized.

- Project-2: **Many-body localization and thermalization** (Prof. Arti Garg)

  Abstract: According to the seminal work by P.W.Anderson, in a non-interacting disordered system quantum-interference among impurity scattered paths might result in a diffusion-less situation due to localization. The question of immense interest, that has remained unanswered for decades after Andersons work, is what happens to Anderson localization when both disorder and interactions are present in a system. It is the localization in interacting many-body interacting system is known as Many-body localization. The MBL phase and the MBL transition are unique for several reasons and challenge the basic foundations of quantum statistical physics. A hallmark of MBL is its non-ergodicity, due to which an isolated quantum system in MBL phase does not thermalize with rest of the system.

  In this project, student will first review the basics of localization and MBL. In second term, student should analyze diffusivity in simple models of MBL.

- Project-3: MAGNETISM IN GRAPHENE (Prof. Kalpataru Pradhan)

  Abstract: TBG

- Project-4: **Bouncing Cosmology: Recent progresses and its future** (Prof. Amit Ghosh)

  Abstract: TBG

- Project-5: **Application of neural network to train the equation of state** (Prof. Bijay Agrawal)

  Abstract: The properties of neutron stars and finite nuclei are mainly governed by the nature of the equation of state. The bulk properties of the finite nuclei usually constrain the equations of state for the symmetric nuclear matter. Their behaviour at large asymmetry and at higher densities can be constrained only with the accurate knowledge of the properties of the neutron stars which are presently poorly known.

- Project-6: **Fermions in a Rindler Geometry** (Prof. Arnab Kundu)

  Abstract: The goal will be to understand a recent proposal for calculating correlator in a Schwinger-Keldysh framework in Holography, extend it to fermionic degrees of freedom in a Rindler geometry.

- Project-7: **Some Aspects of Field Theory in a Magnetic Field** (Prof. Pradip Roy)

  Abstract : In this review we shall derive the free propagators of charged scalar bosons and fermions in a magnetic field. Using Dyson-Schwinger equation the effective propagator of bosons/fermions will be obtained in the interacting theory. For simplicity we discuss a toy model to calculate one loop self-energy of neutral scalar boson from which we derive the effective propagator in a magnetic field. The spectral properties, such as mass, decay width will be derived in the presence of an external magnetic field. We shall briefly outline the calculation of gauge boson self-energy (photon) in a magnetic field. Inclusion of temperature and/or density in these type of calculations will also be illustrated.
  (Keywords : QFT, FT at finite temperature and non-zero magnetic field)