

**Department of Physics**  
**School of Mathematical Sciences**  
**Ramakrishna Mission Vivekananda Educational and Research**  
**Institute**



PO Belur Math, Dist. Howrah, Pin 711202, West Bengal

**Workshop in Theoretical Physics**

**December 18-21, 2017**

**Organizers:**

**Debashis Gangopadhyay**  
**Abhijit Bandyopadhyay**  
**Shamik Gupta**

**Scientific Report on the Workshop**

The event, modeled as a unique and an intense workshop, featured several expository lectures on frontier areas of research by experts of repute chosen from leading research institutes and universities across India as well as from the host organization, the Department of Physics, RKMVERI. There were both experienced and young researchers delivering lectures in the workshop. On a typical day of the workshop, there were four 1-hour long talks, two in the morning and two in the afternoon, and a 1.5-hour long interactive evening talk as part of a special 5-lecture course. The workshop was aimed at Ph. D., M. Sc. and third-year B. Sc. students.

*Lectures were delivered on a wide range of topics chosen from as diverse areas as condensed matter physics, gravitation, non-linear dynamics, statistical physics, and quantum computation.*

**Professor N. Mukunda from IISc., Bangalore** gave a set of 5 lectures on a topic that is quite foundational, yet rarely discussed in text books on classical mechanics, namely, the topic of Dirac theory of constrained dynamical systems.

**Professor Mustansir Barma from TIFR, Hyderabad** emphasized the importance of fluctuations in bringing about the remarkable universality observed near the critical points of many systems (fluids, magnets ...). An interesting highlight of his lectures was the revelation that although ordering is in general destroyed by fluctuations larger than the average, there are notable exceptions in which a system exhibits the phenomenon of fluctuation-dominated phase ordering, whereby fluctuations and order coexist.

**Professor Vijay Shenoy from IISc., Bangalore** introduced in his lectures the field of topological insulators, a topic of huge recent interest. The key results conveyed in his two lectures were: (i) there are more than one type of band insulators in one dimension, which can be distinguished by the topology of their ground-state wave-functions, and (ii) a summary of the “periodic table of topological phases,” and an exploration of the ten-fold symmetry classification of Fermionic systems.

**Professor Arvind from IISER, Mohali** lectured on quantum information and quantum computation. He introduced the notion of quantum entanglement and its quantitative measures based on entropy and partial transpose. Further, he introduced the idea behind quantum cryptography protocols.

The lectures of **Professor Krishnendu Sengupta from IACS, Kolkata** were devoted to the area of non-equilibrium dynamics around quantum critical points. In his lectures, he covered the basic aspects of non-equilibrium dynamics of closed quantum systems, and demonstrated that they may have relevance in the physics of ultracold atoms.

**Professor Ram Ramaswamy from JNU, New Delhi** decided to talk about the very interesting topic of collective synchronization in dynamical systems. He described the phenomenon in coupled linear and nonlinear dynamical systems, including those wherein the dynamics is chaotic, when the coupling is linear and nonlinear, and when there is time delay in the coupling.

In the wake of recent upsurge in interest in gravitational waves, **Professor Pankaj Joshi from TIFR, Mumbai** talked about Black Holes, discussing the current status of research on gravitational collapse of massive stars in the Universe in the framework of Einstein's theory of general relativity, the formation of black holes and naked singularities and their observational, astrophysical and quantum gravity implications.

**Dr. Shamik Gupta from the Department of Physics, RKMVERI**, discussed how one may study theoretically the problem of spontaneous synchronization using tools from dynamical system theory and statistical physics. The talk was planned as a tale of a fascinating journey along a winding path that wanders through mathematical biology, kinetic theory, bifurcation theory, and plasma physics.

All the lectures of the workshop have been video-taped and would soon be uploaded to a dedicated YouTube channel.

We had arranged for online submission of applications. There was an overwhelming response to our announcement of the workshop, and within the span of less than a month, we received as many as 150 applications from all across India. For logistic reasons, we had to limit the number of participants, which we achieved by making a careful selection based on the academic performance of the applicants. In the end, there were participants from all the leading academic institutions, including the IIT's, the IISER's, NISER, IISc., IACS, SNBNCBS, St. Xavier's, Calcutta University, JNU, Jadavpur University, Presidency University, RKM Vivekananda College Chennai, IEST, NIT, University of Hyderabad, etc. In addition, there were Ph. D. as well as first and second year M. Sc. students from the Department of Physics, RKMVERI who participated in the workshop. The total number of students, both local and outstation, who attended the workshop was 55.

A particularly appreciated aspect of the workshop has been the opportunity that the participants and the lecturers had to engage in animated discussions. The workshop was rather timely, allowing for a fast dissemination of recent progress in theoretical physics across various disciplines to young researchers, thereby contributing significantly towards the outreach efforts of the hosting organization. All the lecturers sent back very encouraging feedback on the workshop, emphasizing in particular the fact that they were very glad to observe that the participants did not hesitate to ask questions and clarify their doubts. The participants also expressed a final positive opinion that was well beyond a formal congratulation.

We conclude by expressing our heartfelt gratitude to RKMVERI, and in particular, to our Honorable Vice Chancellor Swami Atmapriyanandaji Maharaj for support and encouragement in every way conceivable. We want to record a special word of acknowledgement to all the support staffs of the University for helping us in making the workshop a great success. We plan to make the organization of similar workshops a regular annual event of the department.