



डा. बी आर अम्बेडकर राष्ट्रीय प्रौद्योगिकी संस्थान  
Dr. B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY  
जी टी रोड बाई पास, जालन्धर-१४४०११, पंजाब (भारत)  
G T Road Bye Pass, Jalandhar- 144011, Punjab (India)  
भौतिकी विभाग  
DEPARTMENT OF PHYSICS

Date: 29-10-2020

**Subject: Brief summary of the one week online short term course on “Current trends in condensed matter physics” dated 25th to 29th September 2020**

During dated 25th to 29th September 2020, we have generated a wealth of information and experience in this STC. The brief Summary is the followings:

**Day-1 (25<sup>th</sup> Sep, 2020) Inaugural:**

The short term course was inaugurated by **Prof. L. K. Awasthi**, Director, Dr. B. R. Ambedkar National Institute of Technology, Jalandhar and welcome Honourable chief guest **Prof. T. V. Ramakrishnan** (Padma Shri). He encouraged the participants and the organizers for attending and conducting the short term course (STC) online. The participants were welcomed by **Dr. Harleen Dahiya**, Head Department of Physics. **Dr. Vinod Ashokan** then briefed the participants about the objective and motivation for organizing the STC. The course was registered by 763 participants including faculties, Postdocs, PhD students and Master students from various leading academic and research institutes across India and abroad. In this course 10 eminent speakers from some esteemed Indian research and academic institutes have participated as resource persons by delivering their expert talks.

**Session – 1 (Morning)**

**Prof T.V. Ramakrishnan**, (Padma Sri, Fellow of Royal Society, Distinguished Associate, Indian Institute of Science, Bangalore) in his key-note address motivated the students by introducing the basics of the theoretical condensed matter physics with the special emphasis on the importance of the field. He delivered a talk on "**Metals with strong electronic correlation**" in which he summarized present (working) picture of the metals, mentioned some properties of the strongly (electron) correlated metals. He then discussed some theoretical attempts at making sense of their properties with some characteristic applications.

**Session – 2 (Evening)**

**Dr. Navinder Singh** (Physical Research Laboratory (PRL), Ahmedabad) delivered a talk on “**An introduction to conventional and unconventional superconductivity**”. In which he shared some background to weakly and strongly correlated system and then introduction to the conventional superconductivity which includes details discussion on BCS theory of Superconductivity. A key highlight of his talk was the field of unconventional superconductivity, he then discussed the materials and electronic structures and problems of unconventional superconductivities. He summarizes the leading theories for the mechanism of unconventional superconductivity, and with some experimental facts. Among them the Hubbard Model for Strongly Correlated Systems, Anderson's Model and related developments specially about Cuprates, and High Transition Temperature superconductivity, Idea of Kohn – Luttinger and Cluster extensions of DMFT. He addressed the present status of the current theories of unconventional superconductivity and presented some of their Investigations and results.



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**Day-2 (26<sup>th</sup> Sep, 2020):**

**Session – 3 (Morning)**

**Prof. R. K. Moudgil** (Kurukshetra University, Kurukshetra) delivered a talk on "**Quantitative Assessment of Exchange-correlations via Coulomb Drag in Electron-electron and Electron-hole Bilayers**" in which he shared light on the effects of many-body correlations crucial role in determining the physical properties of materials. He discussed the Coulomb drag phenomenon with recent experimental probe, physical realization of bilayers in 2D gas using GaAlAs -GaAs - GaAlAs Heterostructures. In his talk he presented recent theoretical results obtained by his group on drag resistivity of the electron-electron and electron-hole bilayer systems by considering both the dynamics and temperature dependence of intra- and inter-layer correlations. The drag resistivity is calculated by considering the contribution from direct scattering processes using the semi-classical Boltzmann approach, with a dynamically screened inter-layer interaction determined within the framework of temperature-dependent dynamical self-consistent mean field approach of Singwi. At the end he demonstrates clearly the importance of including dynamical nature of exchange-correlations to have a reasonable account of the measured drag resistivity.

**Session -4 (Evening)**

**Prof. Tulika Maitra** (Indian Institute of Technology, Roorkee) started her talk with brief introduction to density functional theory and discussed various model parameters that can be derived from such calculations. She then highlighted their recent calculations and results in three different classes of compounds: (1) Magnetically driven type-II multiferroics (2) Geometrically frustrated magnetic materials (3) Magnetic exchange driven type-II Weyl semimetals.

Among them she discussed the nature of spiral state and corresponding ferroelectric response in the incommensurate magnetic phase of type II multiferroics. The interesting interplay among magnetism, charge transport and optical properties in the layered triangular-lattice antiferromagnet using density functional theory and Boltzmann transport theory is discussed in details. Prof Maitra demonstrated that their DFT calculations were able to match/predict experimental observations very well.

**Day-3 (27<sup>th</sup> Sep, 2020)**

**Session – 5 (Morning)**

**Prof. S. P. Das** (Jawaharlal Nehru University, Delhi) lectured on "**Mechanics of many: Discrete and Continuum descriptions**". He discussed how starting from simple laws of mechanics, we understand the dynamics of many particles and develop a microscopic level model of physical phenomena observed in the macroscopic world. He explained such theories are important tools for explaining transformation between different phases of matter. He introduced states of matter, Brownian motion, correlation Functions (static and dynamic). He discussed continuum field theoretic model essential for understanding



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physics of many different scales, both spatial and temporal. Its use for understanding the role of conservation laws and detailed balance in the equilibration of a fluid consisting of passive units as well as units which are self driven or active.

**Session – 6 (Evening)**

**Prof. K. N. Pathak** (Punjab University Chandigarh), delivered a talk on “**Metallic Quantum Wire**”. He explained the Jellium Model of metallic electron gas and some of its properties in addition to behavior of electrons in crystalline solid. Subsequently, he discussed the one-dimensional quantum Fermi gas with Coulomb interaction. He discussed the experimental realization of quasi 1D model systems. The behavior of one dimensional physics with momentum distribution and particle-hole excitation picture. He explained how to confine the electron gas in one-dimension theoretically. Later he presented some of his latest results that are pair correlation function, structure factor and momentum distribution function of 1D quantum electron wire obtained using Quantum Monte Carlo method. He showed in the high density limit, the structure factor and exchange energy is analytically obtained. Further he showed these are exact results obtained which perfectly agree with QMC simulation. Some aspects of Tomonaga-Luttinger behavior of 1D electron gas is also discussed

**Day – 4 (28<sup>th</sup> Sep, 2020)**

**Session –7 (Morning)**

**Prof. Sumathi Rao** (Harish-chandra Research Institute (HRI) Allahabad) delivered a talk on “**Topological Phases of Quantum Matter**”. She chronologically introduced the development of the field of topological phases in the last 10-15 years. She gave an overview of the basic ideas in this field, starting from the quantum Hall effect, and then leading to topological insulators, topological superconductors and Weyl semi-metals. She end with a brief mention of the current frontiers in the field.

**Session – 8 (Evening)**

**Prof. Vikram Tripathi** (Tata Institute of Fundamental Research, Mumbai) delivered a talk on “**Spinons in magnetically ordered phase: on MBL Approach**”. He discussed Quantum spin liquids, spin-1/2 honeycomb lattice Kitaev model etc. Then he discussed the realization of Kitaev physics in material systems, which has been proved quite challenging because of the presence of competing spin interactions that result in magnetic order. Prof Vikram presented some of his recent work in which to understand the nature of quasiparticles in a real Kitaev system, they have developed a new approach, based on the many-body localization ideas, of directly comparing the many-body states of a Kitaev-Heisenberg model with pure Kitaev states as well as magnon-like excitations of a spin-density wave. They have presented their main finding that over a range of strengths of the Heisenberg perturbation where spin-density wave order is present; the low-lying excitations resemble Kitaev states rather than magnons.



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**Day – 5 (29<sup>th</sup> Sep, 2020)**

**Session 9 (Morning)**

**Prof. Sunita Shrivatava** (Punjab University Chandigarh), delivered a talk on “**Properties of Topological Semimetal Lanthanum Monopnictide**” She summarizes the electronic structure topology of crystalline materials which has emerged as a major new theme in the modern condensed matter physics in the last decade.

She presented few results of her ongoing present research work, among them the first principles calculations have been carried out to study the structural, electronic and thermoelectric properties of LaBi by making use of density functional theory (DFT) combined with semiclassical Boltzmann transport theory. In their recent work they found the topological character of LaBi is found to be in agreement with the available theoretical and experimental studies.

**Session 10 (Evening)**

**Dr Sanjeev Kumar** (IISER Mohali) delivered a talk on “**Magnetic Skyrmions in Rashba coupled Hund's metals**”, during his talk he discussed Magnetic Skyrmions are topologically stable textures that have been observed, using a combination of microscopic techniques, in thin films of a variety of magnetic metals. These are being considered as building blocks of next-generation low-power data storage and processing devices. The talk has provided a microscopic origin of these unusual magnetic textures.

**Links to all the recorded lectures are mentioned in the website for ctcmp2020**

**Website:** <https://sites.google.com/prod/view/ctcmp2020>

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