

Report on

Science Academies' Refresher Course on Statistical Physics

18 - 30 December, 2017

Sponsored by:

Indian Academy of Sciences, Bangalore

Indian National Science Academy, New Delhi

The National Academy of Sciences, Allahabad

Organized by:

Sir P. T. Sarvajanik College of Science, Surat



Introduction:

A Two-Week Refresher Course on "Statistical Physics" was organized by Sir P. T. Sarvajanic College of Science, Surat from 18th to 30th December, 2017. The course was sponsored by Indian Academy of Sciences, Bangalore, the Indian National Science Academy, New Delhi and the National Academy of Sciences, Allahabad. Twenty seven participants, not only from Gujarat but also from other states, like Punjab, Bihar, Uttar Pradesh, Jammu & Kashmir, Delhi, Kerala, Karnataka etc., took part in this refresher course with full zest and vigour. Six eminent resource persons and the Course Director Prof. Deepak Dhar, Professor, Department of Physics, IISER, Pune conducted different sessions during the course.

Team behind the successful event:

Course Director: Prof. Deepak Dhar, Professor, Department of Physics, IISER, Pune.

Course Coordinator: Dr. Pruthul Desai, Principal, Sir P. T. Sarvajanic College of Science, Surat.

The eminent Resource Persons included:

- Prof. Sriram Ramaswamy (IISc, Bangalore)
- Prof. Kavita Jain (JNCASR, Bangalore)
- Prof. Debashish Chowdhury (IIT, Kanpur)
- Prof. Kushal Shah (IISER, Bhopal)
- Prof. Sanjib Sabhapandit (RRI, Bangalore)
- Prof. Sanjay Puri (JNU, Delhi)



Inaugural Function:

The inauguration function of the "Science Academies' Refresher Course on Statistical Mechanics" was held on 18th December, 2017 at the Taramoti Hall, Sir P. T. Sarvajani College of Science, Surat. Prof. Deepak Dhar - the Course Director, welcomed the gathering and narrated the significance of the Refresher Course. He particularly pointed out that teachers have a pivotal role to play in higher education. To be relevant in this fast changing world, teachers will have to keep themselves updated with the latest research and should also develop good command over the fundamentals of the subjects which they teach. This refresher course is one of the many efforts taken up by the academy in improving the basics of the teachers across the country in the field of statistical physics. He added that in the course schedule, tutorial sessions have to be kept specifically with a purpose to interact with the teachers and discuss problems that they face in teaching statistical physics and may be chalked out possible remedies. He thanked all the participants for showing interest in the course. Prin. Dr. Pruthul Desai, the course coordinator introduced the resource persons. He told the audience that we are lucky to have such eminent persons as a part of the course. He thanked the academy, the management of the College, the teaching and non teaching staff members for making the course a grant success.

Course details:

- The Refresher Course was designed to:
 - 1) Provide insight and understanding regarding the key concepts of statistical physics
 - 2) The course was aimed at the college teachers, teaching statistical physics at the B. Sc. /M. Sc. level



- 3) To cover basic principles and techniques, in a pedagogical manner, through lectures and tutorials, with illustrative problems.

Sessions:

➤ **Prof. Kushal Shah:**

The course was initiated through a lecture delivered by Prof. Kushal Shah. He started with an overview of Probability theory and emphasised on probability distribution. He also explained classical and quantum aspects of the theory. Prof. Kushal Shah made it sure that the session became interactive by asking thought provoking questions to the participants. Further, during his sessions, Prof. Shah had explained in detail Gaussian distribution, Maxwell-Boltzmann distribution, Conditional Probability, Baye's theorem etc.

➤ **Prof. Sanjay Puri:**

During his sessions, Prof. Sanjay Puri discussed the basic principles of covered phase transitions and critical phenomenon. He introduced the topic by asking two basic questions: (i) Why do we have a physical system with different phases? and (ii) What happens at the boundaries between two phases? Further, Prof. Puri discussed, at length, topics such as Correlation Function, typical phase diagram of a magnet-ferromagnet, BCS theory of superconductivity, derivation of phase diagram from microscopic model, mean field theory and transfer matrix method for Ising model etc.

➤ **Prof. Debashish Chowdhury:**

Prof. Debashish Chowdhury began his talk by introducing "Markov Process". A Markov Process is a random process indexed by time and

with the property that the future is independent of past, given the present. Markov processes, named for Andrei Markov, are among the most important of all random processes. In a sense, they are the stochastic analogues of differential equations and recurrence relations, which are of course, among the most important deterministic processes. A stochastic process is a sequence of events in which the outcome at any stage depends on some probability. A Markov process is a stochastic process with the following properties: (a) The number of possible outcomes or states is finite. (b) The outcome at any stage depends only on the outcome of the previous stage. (c) The probabilities are constant over time.

During his sessions, Prof. Debashish Chowdhury also discussed Markov chain, the matrix M which is called a transition matrix, absolute vector and probability vector.

➤ **Prof. Sanjib Sabhapandit:**

Sessions on Quantum Statistical Mechanics were conducted by Prof. Sanjib Sabhapandit. He concentrated on thermodynamics. He had discussed about microscopic and macroscopic states. He also explained canonical and micro-canonical ensemble for two level systems in detail. Participants were enlightened by him on some more interesting topics such as graphical solution of transcendental equations, position basis, energy eigen basis, density matrix, etc.

➤ **Prof. Sriram Ramaswamy:**

Non-Equilibrium Statistical Mechanics was introduced to the participants by Prof. Sriram Ramaswamy. He elucidated brownian motion and lagrangian equation. Some difficult topics in particular,

random distribution on Fokker-Planck equation, dynamics at thermal equilibrium, Fourier transformation in time domain, randomization group, mobility and self propulsion were explained in a simple and lucid manner.

➤ **Prof. Kavita Jain:**

With Prof. Kavita Jain, the participants could explore critical phenomena. She discussed on gas-liquid transition, magnetic transition, randomization group, phase diagram, Gibb's free energy, ideal gas equation, Maxwell construction, Ising model, spontaneous magnetization, correlation function and critical exponents during her sessions.

➤ **Tutorial session by Prof. Dipak Dhar:**

Every day, the last session was a tutorial session which was conducted by the Course Director Prof. Dipak Dhar. Prof. Dhar was quite comprehensive during the tutorial sessions. The sessions were purely interactive type in which the participants were free to discuss anything related to Physics. He discussed all the questions raised by the participants regarding the topics that were taught. He assigned problems to the participants and in turn asked the participants to solve them on the board. He also explained to the participants how to make the teaching of statistical physics more interesting. He particularly stressed that it can be made interesting and lively by establishing connection between the theory and experiment. He further threw light on Ising model, magnetic system, ensemble properties of states, Boltzmann's factor, symmetry breaking, phase transition, phase transition control parameter, micro states vs macro states, free energy,

need of quantum statistics, pure state and mixed state etc. Most of the participants had a very lively, active and free discussion with him.

- During this course, the evening sessions for two days of the second week, were allotted for the presentations by the participants. They were informed to give presentations for maximum of seven minutes on a topic of their choice. Two best presentations, one from student category and one from the teacher's category, were selected. The winners were felicitated in the valedictory function.

Excursion Trip:

- Besides this, an excursion trip was also arranged. In that, they visited places like Sardar Sarovar Dam and other Cultural Centers on Sunday, 24th December. All the participants, along with the resource persons, joined in it and they were accompanied by the faculty members of the college.

Feedback:

The lectures were well received and enjoyed by all the participants. All of them gained a lot from this course which was reflected in the feedback given by the participants. Faculty members of Sir P. T. Sarvajani College of Science also attended the sessions. All in all, it was a quite fruitful and successful course.

Valedictory Function:

The Valedictory function of the "Science Academies' Refresher Course on Statistical Mechanics" was held on 30th December, 2017 during the post lunch session. The participants shared their experience and gave their suggestions. Prof. Debashish Chowdhury, Prof. Dhar and Dr. Kusumben Desai, former Principal, Sir P. T. Sarvajani College of Science distributed certificates to the



participants. The Course Director Prof. Deepak Dhar presented the Course Report. Course Coordinator Dr. Pruthul Desai delivered the valedictory address. Prof. Viresh Thakkar proposed the vote of thanks and recorded the support and cooperation extended by the SES Administration, Alumni Association of Sir P. T. Sarvajani College of Science, Course Director- Prof. Dhar, resource persons and Participants. He extended a special thanks to all the three academies for sponsoring the course.




Principal
Sir P. T. Sarvajani College of Science,
Surat.