Report
Academies Refresher Course on Quantum Mechanics
at Physics Department, IIT Roorkee

A refresher course on Quantum Mechanics was organized at the Physics Department of IIT Roorkee from November 28 to December 12, 2013. The course was sponsored by the three science academies of the country: Indian Academy of Sciences, Bangalore, Indian National Science Academy, New Delhi and The National Academy of Sciences, Allahabad. The Director and the Convener of the course were respectively Prof. Deepak Kumar (JNU, New Delhi) and Prof. Ishwar S. Tyagi (IIT, Roorkee).

Though 40 outstation participants were admitted to the course, 26 actually attended the course in full. In addition there were 22 local participants, of which 15 were research scholars from Physics and Chemistry departments of IIT and 7 were students of M.Sc. and M. Tech. programmes. The course consisted of 59 one-hour lectures and tutorials spread over 13 working days. The course was mainly basic Quantum Mechanics at the M.Sc. Level with some new topics. The distribution of lectures/tutorials among various topics was briefly as below.

1. Basic Quantum Mechanics .......... 35 lectures
2. Quantum Technologies ............ 5 lectures
3. Quantum Information .............. 5 lectures
4. Quantum Gases, 2nd Quantization 5 lectures
5. Density Functional Theory ....... 5 lectures

The resource persons for basic Quantum Mechanics were: Prof. I. S. Tyagi (IIT, Roorkee), Prof. Debajyoti Choudhury (Delhi University), Prof. Deepak Kumar(JNU), Prof. Dilip G. Kanhere (University of Poona). Prof. Arvind (IISER, Mohali) gave lectures on Quantum Information, Prof. Saikat Ghosh (IIT, Kanpur) on Quantum Technologies and Prof. Sushil Auluck (NPL, New Delhi) on Density Functional Theory. Prof. Deepak Kumar covered Second Quantization and Quantum Gases. In addition Prof. S.K. Joshi gave the inaugural lecture on the history of Quantum Mechanics, Prof. Rajaraman gave two lectures on Identical Particles and Prof. A.K. Jain gave one lecture on Symmetries and Nuclear Spectra.

We also had four lively sessions where participants contributed. The first session was on the theme: Challenges of a Physics Teacher. Here many participants described their experiences and ways to make physics exciting to students and involve them in discussions. In two sessions some participants made presentations about their research and teaching work. During the valedictory session, we obtained some inputs from the participants about the course and suggestions for its improvement. A frequent suggestion was that there should be courses devoted to pedagogy in physics. Several participants expressed that an intense and focused course is very useful for their research and teaching. Some felt that similar courses in other topics like Electromagnetic theory would be useful.

It was very heartening to see the enthusiasm of the participants and lecturers. Many one-
hour lectures went on up to one and a half hours as discussions and interruptions were frequent. The new topics on Quantum Information and Quantum Technologies were greatly appreciated by many, and several persons desired that these topics should become a part of Quantum Mechanics courses. The inclusion of Density Functional theory was also appreciated due to its wide-spread use in material science, chemistry and biology. There was much demand for notes, however these could not be provided. All the participants and lecturers were given a copy each of the following books.

1. Principles of Quantum Mechanics by R. Shankar
2. Principles of Quantum Mechanics by Ishwar S. Tyagi

Ishwar S. Tyagi

Deepak Kumar
Course Plan

Module – I (6)
Basic Formulation of Quantum Mécanics: Dual nature of matter and light, wave packets, Postulates of Quantum Mechanics - State vector and Hilbert space, Observables as operators, Probability interpretation, Time evolution and Schrodinger equation.

Module - II (5)
Schrodinger equation, Simple one – dimensional problems: particle in a box, tunneling problem, harmonic oscillator, Two – level problem.

Module – III (10)
Symmetry in Quantum Mechanics, 3-dimensional systems, angular momentum algebra, 3 – D well, Hydrogen atom, addition of angular momenta, Spin.

Module – IV (10)

Module – V (5)
Identical particles, two – particle problems, exchange interactions, formalism of second quantization.

Module – VI (5)
Quantum technologies: Creation of entangled states of atom and light. Trapping of atoms, Recent experiments

Module –VII (5)
Quantum computation, qubits, one and two qubit gates, simple quantum algorithms, quantum cryptography.

Module – VIII (5)
Density functional theory, basic principles and equations, representative applications to atoms and solids.

Lecturers

1. Ishwar S. Tyagi
QM-A
2. Debjyoti Choudhury
QM-B
Schrodinger equation, tunneling problem, Symmetry in Quantum Mechanics, 3-dimensional systems, angular momentum algebra, Hydrogen atom, addition of angular momenta, Spin, Two – level problem.

3. Dilip Kanhere
QM-C
Perturbation theory, time–independent problems, time–dependent perturbation theory, atom–light interaction, scattering theory. numerical methods.

4. Deepak Kumar
QM-D
State vector and Hilbert space, Postulates, Identical particles, formalism of second quantization. two – particle problems, exchange interactions, quantum gases.

5. Saikat Ghosh
Quantum Technologies

6. Arvind
Quantum Information

7. Sushil Auluck
Density Functional Theory

In addition there were special lectures by Prof. S. K. Joshi (1), Prof. R. Rajaraman (2) and Prof. A. K. Jain (1).
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Lecturers:
Prof. S. K. Joshi (SKJ); Prof. I. S. Tyagi (IST); Prof. Debajyoti Choudhury (DC);
Prof. Deepak Kumar (DK); Prof. D. G. Kanhere (DGK); Prof. R. Rajaraman (RRR)
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32. Mr. Deepak Kumar

33. Mr. Avijeet Ray

34. Ms. Priti

35. Ms. Vidhi Mann

36. Mr. Shivam Singh

37. Mr. Varun Kundi

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