Quantum Measurement Theory and the Uncertainty Principle

Overview:

Quantum measurement is one of the most fundamental notions in quantum theory. This course focuses on a mathematical theory of finite quantum measurements, for which we assume that the state space of the measured system is a finite dimensional Hilbert space and that the possible outcomes of a measurement are a finite set of real numbers.

We develop the theory in a deductive manner from the basic postulates for quantum mechanics and a few plausible axioms for general quantum measurements. We derive an axiomatic characterization of all the physically realizable finite quantum measurements. Mathematical tools necessary to describe measurement statistics such as POVMs and quantum instruments are not assumed at the outset, but we introduce them as natural consequences of our axioms.

We discuss repeatability and approximate repeatability of measurements in this general formulation. The original formulation of Heisenberg's uncertainty principle, stating that the product of the errors of simultaneous measurements of two observables has a lower bound determined by their commutator, is derived under an additional assumption of approximate repeatability, but it is not valid in general. A universally valid form of Heisenberg's uncertainty principle is derived from the general theory. Experimental confirmations on the violation of the original formulation and the validity of the new formulation are discussed.

Course Objectives:

- To enable the participants to develop an understanding the deductive structure of general theory of quantum measurement.
- To facilitate the participants to acquire mathematical methods of quantum measurements such as POVMs and quantum instruments.
- To provide exposure to the new approach to Heisenberg's uncertainty principle.
- To enhance the capability of the participants to assess the significance of quantum measurement theory in the study of quantum mechanics.

Modules	**A: Quantum Measurement theory : December 11 – December 13** **B: Universal uncertainty principle : December 14 – December 15** **Number of participants for the course will be limited to fifty.**
You Should Attend If…	▪ You are in your final year in MSc physics ▪ You are PhD or postdoc. in quantum information theory. ▪ You are faculty or scientists and want to learn quantum measurement theory. ▪ You are a Physics/chemistry/engineering graduate/researcher interested in quantum science and its applications.
Fees	The participation fees for taking the course is as follows: **Faculty and Scientists from Academic Institutions: Rs.4000/-** **Participants from Industry/Consultancy Firms: Rs. 7,500/-** **Research Scholars: Rs.3000/-** **Bachelors and Masters student: Rs. 2000/-** **Participants from abroad: US$ 500** The above fee includes all instructional materials, computer use for tutorials and assignments, laboratory equipment usage charges, 24 hr free internet facility, and food (Breakfast, Lunch, Dinner & Refreshments). The participants will be provided with accommodation on payment basis provided the participants have to inform @ iro.office@iiserkol.ac.in seven days prior to the Start of the program.

The Faculty

Masanao Ozawa received his doctoral degree in science from Tokyo Institute of Technology in 1979, where he studied quantum information science and philosophy of science. His early studies established quantum measurement theory based on the notion of quantum instruments, and developed Gaisi Takeuti's Boolean-valued analysis to settle Kaplansky's conjecture in operator algebras using the forcing of cardinal collapsing in set theory. He developed quantum measurement theory to settle the controversy in the 1980s on sensitivity limit for gravitational wave detection, by refuting the quantum limit derived by Heisenberg's uncertainty principle. This confirmed the supremacy of interferometers over resonators, and later led him to reformulate Heisenberg's uncertainty principle with a correct error-disturbance relation. He has been serving as program committee members in international conferences and editorial board members for international journals in these research areas. He has held visiting positions at Harvard University, Northwestern University, and Pavia University. He is currently a Professor of Mathematical Science and Artificial Intelligence at Chubu University, and an Emeritus Professor at Nagoya University. He received the Mathematical Society of Japan Prize in 2008, the Commendation for Science and Technology by the Ministry of Education, Culture, Sports, Science and Technology of Japan in 2010, the International Quantum Communication Award in 2010, and the Medal of Honor with Purple Ribbon from the Cabinet Office of Japan in 2015.

Prasanta K. Panigrahi is the Director and was a Professor (Higher Academic Grade) at Indian Institute of Science Education and Research Kolkata in the Department of Physical Sciences, and has also served in the faculty of University of Hyderabad and Physical Research Laboratory (Ahmedabad) earlier.

He is the Principal Investigator in the prestigious project "Quantum Information Technologies with Photonic Device" under the Quantum Enabled Science and Technology (QuEST) of Interdisciplinary Cyber Physical Systems (ICPS) Programme of the Department of Science & Technology (DST), GOI.

He is an international project evaluator for The Austrian Science Fund, Swiss National Science Foundation, National Academy of Science, Ukraine, National Research and Development Agency, Chile and a national project evaluator for SERB, BRNS, DST, Indo-US Science and Technology Forum, CSIR, and Homi Bhabha Fellowship Council.He is referee for many peer reviewed journals: Physical Review Letters, Physical Review A, B, Journal of Physics, Pattern Recognition Letters, Physics Letter A, Pramana, European Physics Letters amongst many others. He is in the Editorial Boards of `Prayas'-Student's Journal of Physics, Physics Education, Discrete Dynamics in Nature and Society, Journal of Quantum Information Science (JQIS) and Atoms. He is a fellow of National Academy of Science, India.

Course Co-coordinator

Prof. Prasanta K. Panigrahi
Phone: 9748918201
E-mail: pprasanta@iiserkol.ac.in

……

http://www.gian.iitkgp.ac.in/GREGN

……

For course registration please visit:

https://gian.iitkgp.ac.in/GREGN/index

Deadline: 5 December 2023

……

Fees:

Name of the Beneficiary:
IISER Kolkata Project A/c
Name of Bank and Branch:
Indian Overseas Bank, Mohanpur
Beneficiary Account No.:
325001000000002
Bank MICR Code: 700020092
Bank IFS Code: IOBA0003250

……

After successful completion of the course, all participants will get participation certificates. No TA, DA will be provided to the participants.

How to reach:
https://www.iiserkol.ac.in/web/en/contact-us/how-reach/#gsc.tab=0

……

Course Venue:
Lecture Hall Complex Indian Institute of Science Education and Research Kolkata Mohanpur – 741 246, West Bengal, India

……

Contact us: iro.office@iiserkol.ac.in
Phone No: +91 033 6136 0000 (Extn. 2163)