

Department of Physics
St. Philomena's College (Autonomous), Mysuru

Science Academies' 3 day Lecture Workshop on "Quantum Information and Computation" held during 18-20 August, 2018

Report

A 3 day Science Academies' Lecture Workshop on **Quantum Information and Computation** was organized at 2018 at St. Philomena's College(Autonomous), Mysore for College teachers/University teachers/undergraduate and postgraduate and research students during 18-20 August, 2018 at St. Philomena's College(Autonomous), Mysore. The event was directed by Prof. M V N Murthy, Emeritus Scientist, IMSc, Chennai, and locally co-ordinated by Prof. D Revannasiddaiah, Head of the PG Department of Physics.

The event was inaugurated on the 18th morning with Prof. R Srinivasan, Retired Director of UGC- DAE Consortium for Scientific Research, Indore(MP), present as the chief guest alongside the Guest of Honour Rev. Fr. Dr. Bernard Prakash Barnis, the Rector/Manager of the college. The Principal of our College Dr Ruth Shanthakumari, presided over the inaugural session. Also present, besides the participants, were the Course Director Prof. MVN Murthy and the Coordinator Prof. D Revannasiddaiah.

Professor R. Srinivasan during his inaugural address made pertinent remarks on how the multidisciplinary area of quantum information and computation gained importance in recent years. He highlighted the quantum advantage brought out by Peter Shor's algorithm, formulated during 1994, for finding prime factors of a large integer and Grover search algorithm (1996) to. It is shown that it takes around two years to find prime factors of an integer with 232 digits by utilizing hundreds of classical computers. Prime factorization of a 1000 digit integer takes around 20 years. In other words, prime factorization based on any efficient classical algorithm requires exponential running time. But using Shor's algorithm the prime factors of a large integer can be efficiently solved on a quantum computer in polynomial running time. Also, it is known that searching an unsorted database of N numbers using classical algorithm requires a linear search, which is $O(N)$ in time. Grover's quantum algorithm, solves the problem faster with $O(N^{1/2})$ in time. Professor Srinivasan mentioned different physical systems viz., ion traps, NMR, photonic systems and so on, where experimental efforts for realizing quantum computation are going on all over the world.

The lecture series was basically designed with the following modules:

- Basic Quantum Mechanics
- Non-locality and Entanglement
- Quantum Circuits and Algorithms
- Quantum Error Correction, Cryptography and Quantum Simulation

The very first session was a Lecture by Prof. K.S. Mallesh from the Department of Studies in Physics (University of Mysore, Mysuru). In his first lecture he reviewed the basic concepts of quantum mechanics laying the foundation for the other lectures. He discussed in detail the concept of states and dynamical observables, notion of a qubit and its geometric representation on Bloch sphere, pure and mixed density matrices.

Prof. A R Usha Devi from the Department of Physics (University of Bangalore, Bengaluru), reviewed the foundational conflicts that arose in the interpretation of quantum mechanics by discussing the so-called Einstein-Podolsky-Rosen paradox. She began by mentioning about the famous Bohr-Einstein debates which paved way to the 1935 paper by Einstein-Podolsky-Rosen. Local hidden variable models, formulation of Bell inequality and its experimental violation by entangled quantum states was discussed in great detail. She then continued to explain mathematical characterization of entanglement in composite quantum states. Quantum teleportation and quantum dense coding protocols, which require entangled states for their implementation were also discussed.

Professor R. Srikanth (PPISR, Bengaluru) introduced qubit gates, quantum circuits and various quantum algorithms. He explained quantum error correction and quantum cryptography in great detail.

Prof. C M Chandrashekar (The Institute of Mathematical Sciences, Chennai) began by discussing the main ideas behind what is classical computation and quantum computation, highlighting the role of superposition of states. He discussed Grover search algorithm in his first lecture. He then continued, in his second lecture, to discuss quantum simulation based on quantum random walk.

A highlight of the 3 day lecture workshop was the colloquium “Experimental implementation of quantum algorithms in NMR” by Prof. Anilkumar (IISc, Bangalore) on the evening of second day (August 19). He discussed the interesting experimental work carried out in the

NMR lab at IISc, Bengaluru towards implementing various quantum algorithms. As a pioneer in this field, he reviewed the range of experimental work done in his lab and also gave glimpse of the whole field and its future possibilities. Even though the colloquium was held at the end of a gruelling day of lectures in the evening, interest of the participants was held intact.

Overall, this lecture workshop was one of the very successful such meetings. It had the participation of nearly 190 students and teachers not only from local colleges, but also from all the Southern States which is rather encouraging. The participation of students/teachers during discussions was good and the quality of discussions was high. The subject matter seemed to catch the imagination of the students especially. The attendance was high on all days of the workshop including the very last session.

The sweep of the subject matter covered in the workshop was rather ambitious even if it held the interest of the participants. It may be better if future workshops are planned with more focus on either quantum information or quantum computing.

The organisation of the workshop by St. Philomena's College was excellent as always. Such institutions need to be encouraged to conduct more meeting relation to science education.

The Academies must rethink on their policy of supporting the resource faculty only through train travel. In this day and age when air fares are becoming cheaper and only marginally higher than the highest train fare it does not make sense to insist on the faculty traveling by train. For this meeting both Prof. M V N Murthy and Prof. Chandrashekar traveled by air from Chennai to Mysore using their own resources. Prof. Ravishankar dropped out in the last minute and was replaced by Prof. Srikanth. Otherwise, Prof. Ravishankar was supposed to come from IIT Delhi. It would not have made any sense to insist that he should have traveled by train spending four days on the train for a three day workshop! This policy needs to change urgently.

Co-ordinator