QUANTUM VIBES

A newsletter on
Indian Quantum Technology Activities

100 years ago, Satyendra Nath Bose changed physics forever

QuBIT Studio Launch

N Q M

National Quantum Mission

2024
Q1

Editor's Note

Welcome to the Q1 2024 edition of Quantum Vibes, marking our fifth edition as we continue to delve into the captivating realm of quantum technologies. This edition focuses particularly on the pre-proposal initiatives under the National Quantum Mission, showcasing the strides being made in quantum science and its transformative impact across diverse sectors.

One of the highlights of this edition is the in-depth article on "Heralded Single Photon Source," shedding light on this crucial component in quantum communication and computing. We explore how advancements in photonics are driving the development of efficient and reliable single photon sources, paving the way for secure quantum networks and high-performance quantum computers.

In line with the National Quantum Mission's vision of propelling India into a leadership position in quantum science and technology, our newsletter brings you the latest news items showcasing the innovative projects, collaborations, and breakthroughs shaping the quantum landscape. From quantum key distribution and quantum computing algorithms to quantum sensing and metrology, each piece of news underscores the dynamic and vibrant ecosystem driving quantum advancements in our country.

As we celebrate our fifth edition and navigate through the exciting developments in quantum technologies, we invite you to immerse yourself in the quantum vibes of innovation, exploration, and collaboration. Together, let's embrace the frontiers of quantum science and harness its potential to redefine the future of technology, communication, and beyond.

Happy reading!

DR. S.D. SUDARSAN
Editor

MEET THE
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Executive Director,
C-DAC Corporate & Strategy

HERALDED SINGLE PHOTON SOURCE

INTRODUCTION

The interest in Quantum Information Processing and Quantum Computation emerged in the late 1980s, leading to a spike in research and development in Quantum technologies in the 2010s. Single photons have since become a ubiquitous component of almost the majority of the Quantum hardware that we aim to build today.

in a given mode or a single photon is used to represent a qubit. Superpositions of these quantum states can be easily represented, encrypted, transmitted and detected using single photons.

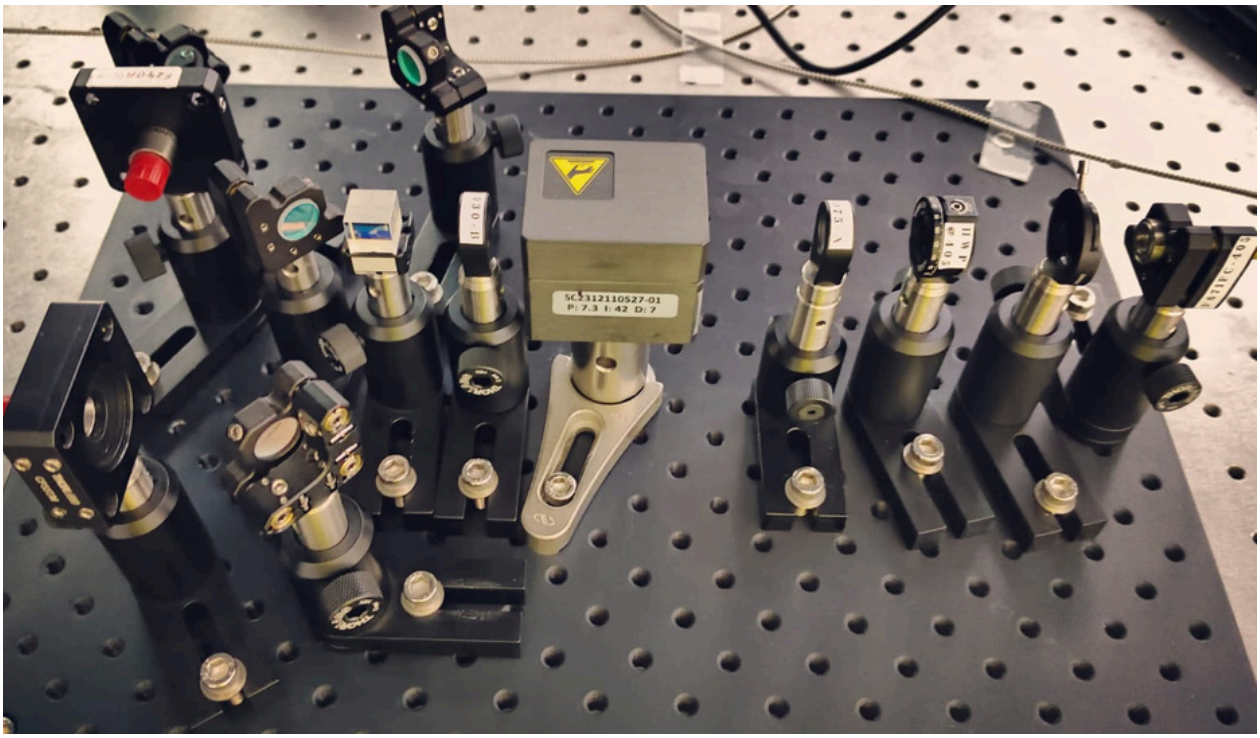


Figure 1: Experimental setup of Heralded Single photon source

There are various ways to generate single photons and then encash it's quantum behaviours like superposition, interference and entanglement to perform computation and communication experiments that have an edge over it's classical counterparts. There are various architectures within the Quantum world like Trap ion and cold atom, Superconducting cavities, Neutral atom, Rydberg atom, Photonics and many among others which have their own pros and cons in relation to the task that has to be carried out.

Photonic quantum systems offer an advantage since they link Quantum computation and Quantum communication in the same framework. In these systems, the unit of light

Linear optical elements are then employed to realize quantum operations and quantum gates. Each linear optical element applies a unitary transformation on a finite number of qubits that are generated. The system of finite linear optical elements constructs a network of Linear optics, which can realize any Quantum circuit diagram or Quantum network based on the Quantum circuit model.

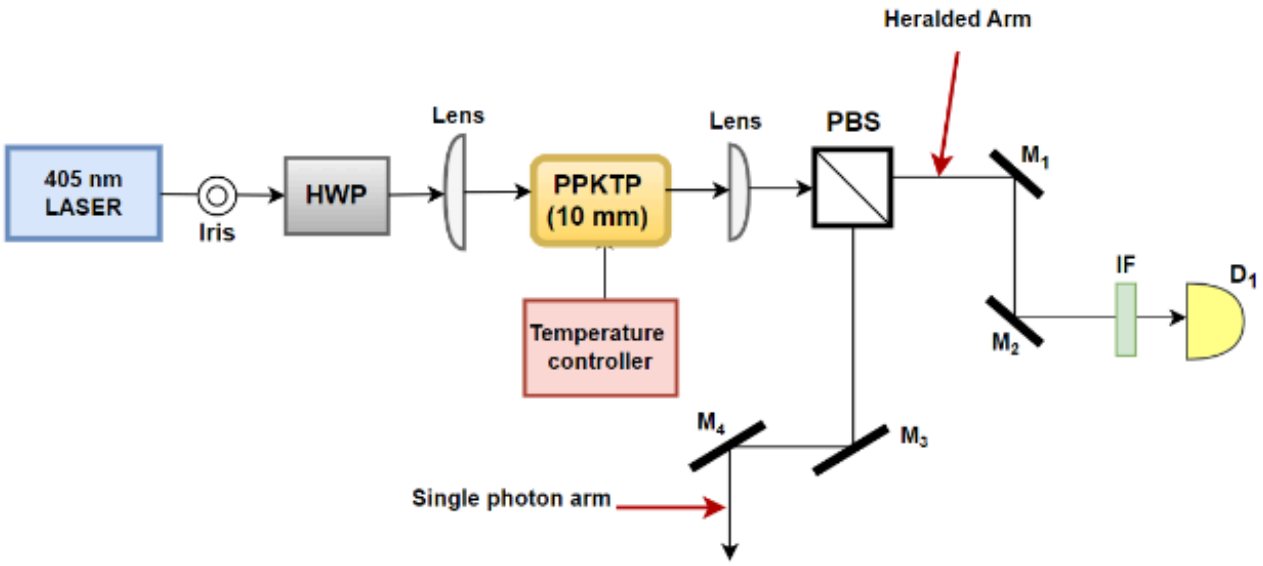


Figure 2: Schematic diagram of Heralded Single photon source

HERALDED SINGLE PHOTON SOURCE

The key enabling technology for experimental quantum optics, Spontaneous Parametric Downconversion (SPDC), remains a practical way to generate high-quality single photons nondeterministically. In this three-wave mixing nonlinear $\chi(2)$ process, a pump photon from a laser has a small probability of being converted into a pair of daughter photons (Signal and Idler). The process must obey the momentum matching equation ($kp = ks + ki$), phase matching condition, and energy conservation law ($\omega p = \omega s + \omega i$).

SPDC is a probabilistic process, but it can be used to produce heralded single photon source, where the presence of a photon is heralded by the detection of its twin. Alternatively, SPDC can produce photon pairs that are naturally entangled in polarization, transverse spatial modes or frequency. With modest effort, it is possible to produce photon pairs with entanglement in a time-bin encoding or even in multiple degrees of freedom simultaneously.

Acknowledgments

We extend our heartfelt gratitude to Prof. Chandrashekar C. M. for his invaluable and timely assistance in constructing the hardware. Prof. Chandrashekar, affiliated with the Optics & Quantum Information Group at IMSc, Chennai, specializes in quantum information processing and computation. At IISc his research group works on experimental photon-based quantum information processing and quantum optics, engineering single and entangled states for diverse quantum applications.

We also express our gratitude to the Ministry of Electronics and Information Technology (MeitY) for their financial support in the development and realization of the Heralded Single Photon Source.

Mr. Sricharan Narasimha
Knowledge Associate
Quantum Technology Group
C-DAC Bangalore

Quantum Currents

News and Updates from the Quantum Universe

"NQM is an ambitious project of government of India"

Prof. Abhay Karandikar
Secretary, DST
Gov. of India

January 17, 2024

National Quantum Mission Governing Board finalises implementation strategy

The inaugural session of the Mission Governing Board (MGB) for the National Quantum Mission (NQM), chaired by Dr. Ajai Chowdhry, Chairman of MGB and Founder of HCL Technologies, convened to discuss the implementation strategy and timelines of the NQM, along with the establishment of the Mission Coordination Cell (MCC). The MCC, to be formed as a coordinating body for the Mission, will collaborate closely with the Mission Secretariat at DST.

DST will identify an institution to host the MCC, considering factors such as merit and existing infrastructure. The MCC will operate under the overall supervision and guidance of the Mission Technology Research Council (MTRC).

Dr. Ajai Chowdhry, Chairman of MGB and Founder of HCL Technologies, emphasized India's potential in quantum technology and stressed the importance of manpower development and supporting startups. Prof A K Sood, the Principal Scientific Advisor to the Government of India, highlighted the necessity of creating a skilled workforce and proposed empowering the Hubs to enhance human capacity.

Dr. V K Saraswat, Member of Niti Aayog, emphasized the need for indigenous development rather than relying on imported systems and urged the industry to contribute to technology and fund sharing. Prof Abhay Karandikar, Secretary of DST, disclosed plans for the establishment of four mission hubs focusing on Quantum Computing, Quantum Communication, Quantum Sensing & Metrology, and Quantum Materials & Devices. These hubs will comprise academia, R&D labs, and industry consortia.

Dr. Akhilesh Gupta, Senior Advisor at DST, and Dr. Ekta Kapoor, Head of FFT Division, presented a detailed implementation plan, which was thoroughly deliberated upon by the committee. The MGB endorsed a "Call for Pre-proposals" to solicit proposals for setting up the four technology hubs under NQM in a consortia format.

The meeting saw the participation of key stakeholders, including Dr. Samir K Kamat, Secretary of DD R&D and Chairman of DRDO, Dr. Rajat Moona, Director of IIT Gandhinagar, Shri Vishvajit Sahay AS&FA, representatives from DOS, DRDO, DAE, Meity, DOT, Dept of Expenditure, and several DST officials.

The Union Cabinet approved the National Quantum Mission (NQM) on April 19, 2023, to be implemented by DST with a total outlay of Rs. 6003.65 Crore over eight years. The Mission's objective is to foster scientific and industrial R&D in Quantum Technology (QT), catalyzing economic growth and positioning India as a global leader in Quantum Technologies & Applications (QTA).

Source: PIB

January 20, 2024

Pre-proposal Launch for Thematic Hubs (T-Hubs) under National Quantum Mission (NQM)

The launch of Pre-proposal call for setting up Thematic Hubs (T-Hubs) aligned with the National Quantum Mission (NQM), led by Secretary Prof. Abhay Karandikar of the Department of Science and Technology (DST), took place on January 20th, 2024, during the 9th edition of the India International Science Festival in Faridabad, Haryana.

The pre-proposal invites academia institutions/ R&D Labs to submit innovative pre-proposals in consortia mode aligned with objectives of the National Quantum Mission (NQM) to setup T-Hubs in

- Quantum Computing
- Quantum Communication
- Quantum Sensing & Metrology
- Quantum Materials & Devices

The deadline for proposal submissions ended on April 12, 2024.

Source: PIB

January 21, 2024

Quantum Computing Initiatives showcased at IISF 2023 and COMSNETS 2024 Events

C-DAC recently presented its Quantum Computing initiatives at two prominent events, the India International Science Festival (IISF) 2023 and the COMSNETS 2024 conference held in January 2024. The participation in these events showcased CDAC's commitment and progress in the field of Quantum Technologies.

At the India International Science Festival, CDAC highlighted its cutting-edge research and development efforts in Quantum Computing, demonstrating the potential of quantum technologies to revolutionize various industries. The event provided a platform for interaction with students, researchers, and industry experts, fostering discussions and collaborations in this rapidly evolving field.

At the COMSNETS 2024 conference, CDAC engaged with a diverse audience of academics and professionals interested in the intersection of communication networks and quantum technologies. The exchange of ideas and insights at this event further enriched CDAC's initiatives in Quantum Computing.

Source: C-DAC

January 23, 2024

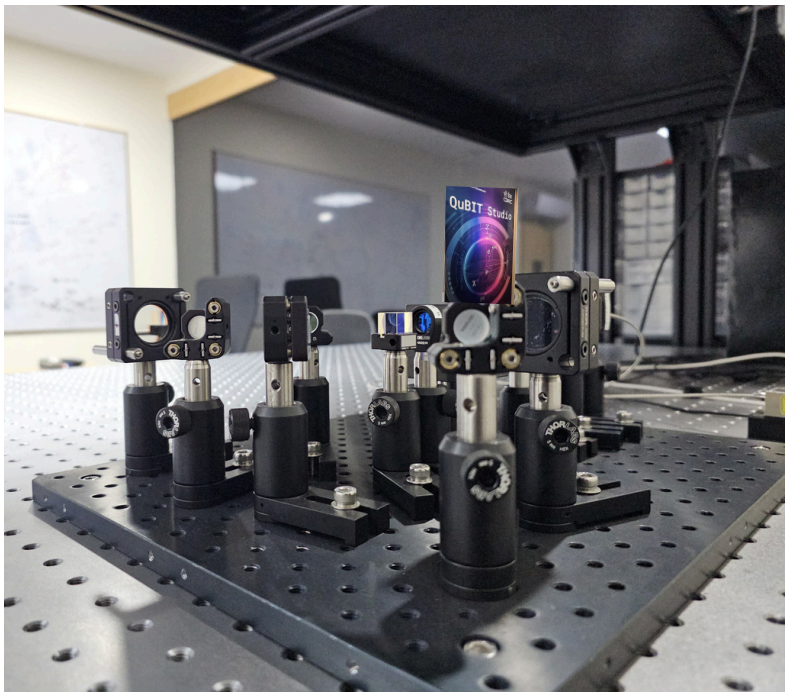
QuBIT Studio launched at C-DAC, Bengaluru

The Secretary of MietY, inaugurated the QuBIT Studio - Quantum Accelerated Computing Laboratory on Tuesday, January 23rd, 2024. The ceremony was officiated by Shri. S. Krishnan IAS, Secretary of the Ministry of Electronics and Information Technology (MeitY), in the presence of Smt. Sunita Verma, Scientist G & GC, MeitY, and Dr. C M Chandrashekar from the Department of Instrumentation and Applied Physics, Indian Institute of Science (IISc).

Dr. S D Sudarsan, Executive Director of C-DAC Bengaluru, briefed the dignitaries on the centre's ongoing endeavors in quantum technology, highlighting collaborative efforts undertaken with various research institutions throughout the nation. Shri. Hari Babu P, Associate Director, elaborated on the role of quantum accelerators and their significance in realizing the next generation of hybrid High-Performance Computing (HPC) and Quantum Computing (QC) systems.

This inauguration marks a significant milestone for C-DAC Bengaluru and underscores its commitment to advancing the field of quantum computing in India. The QuBIT Studio is poised to contribute significantly to collaborative research efforts and the development of innovative applications harnessing the power of quantum technologies.

QuBIT Studio is a dedicated laboratory focused on advancing the field of quantum accelerated computing. This initiative is funded by MeitY under the programme "HPC based Quantum Accelerators for enabling Quantum Computing on Supercomputers."



The primary objective of QuBIT Studio is to develop hybrid computing systems that effectively integrate diverse quantum technologies, such as photonic computation and communication systems, with conventional high-performance computing (HPC) architectures. This approach aims to leverage the strengths of both technologies to harness the full potential of quantum computing and accelerate its practical applications.

January 26, 2024

Faculty Development Program at Kannur University Delves into Quantum Computing

FDP @ Kannur University, Kannur

From January 22nd to January 26th, 2024, Kannur University and C-DAC Bangalore jointly organized an intensive five-day Faculty Development Program (FDP). This collaborative effort focused on the exploration of cutting-edge subjects such as Linear Algebra, Quantum Mechanics, and hands-on experience with Quantum Computing through the use of Quantum Simulator (QSim) and Quantum Network Simulator (QNS).

The event drew around 50 participants from various engineering and science colleges across Kerala, showcasing a strong interest in the burgeoning field of quantum computing. The program featured a blend of theoretical sessions and practical workshops, providing attendees with a comprehensive understanding of quantum computing concepts and tools.

The sessions included deep dives into QSim, Qiskit, quantum algorithms, and quantum network simulation, offering participants a hands-on experience to explore and experiment with quantum computing technologies. The practical aspect allowed attendees to apply their theoretical knowledge in a real-world context, fostering a deeper grasp of quantum computing principles and applications.

During the program, Mr. Henry S, Scientist F at C-DAC Bangalore, conducted an enlightening session on QSim, providing hands-on experience to the participants. His expertise and guidance enriched the understanding of quantum simulation techniques and their applications.

Dr. Naresh Raghava, Senior Project Engineer at C-DAC Bangalore, showcased the capabilities of the Quantum Network Simulator (QNS) through a detailed demonstration. His presentation highlighted the practical aspects of quantum network simulation, offering valuable insights into networking protocols and quantum communication technologies.

Dr. N. S. Sreekanth, Head of the Department of Computer Science at Kannur University, expressed enthusiasm about the program's success in bridging the gap between theory and practice in quantum computing education. He emphasized the importance of such initiatives in preparing faculty members and students for the transformative impact of quantum technologies in the future.

The collaborative and interactive nature of the FDP encouraged knowledge exchange and networking among participants, creating a vibrant learning environment conducive to exploration and innovation in quantum computing.

Source: C-DAC

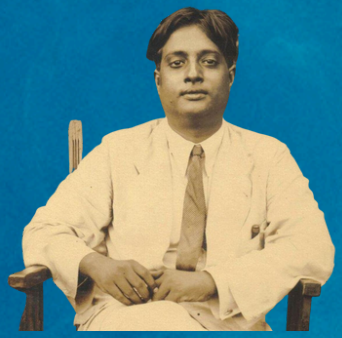
Hundred years ago,

Satyendra Nath Bose

changed physics forever

In the turbulent waters of 1924's physics revolution, a quiet yet brilliant mind was crafting a new chapter in the science of the microscopic world. Satyendra Nath Bose, born in Calcutta in 1894, was not just a mathematician and physicist; he was a pioneer who would leave an indelible mark on the quantum landscape.

As a faculty member at Rajabazar Science College, Bose found himself immersed in a rapidly changing physics paradigm. The works of luminaries like Max Planck, Niels Bohr, and Albert Einstein had shattered the old notions of physics, revealing a world inside atoms that demanded a new understanding. Bose and his colleague Meghnad Saha delved into this new frontier, even overcoming the language barrier posed by German papers to become early adapters of Einstein's theory of relativity.



One particular puzzle captured Bose's attention—the enigmatic Planck's law of black-body radiation. This law, formulated by Max Planck in 1900, described how radiation behaved differently at the microscopic level, challenging classical physics. While Planck had guessed the right formula, its derivation remained elusive and logically inconsistent.

Bose, however, saw beyond the inconsistencies. He realized that energy, just like matter, had to exist in discrete packets or 'quanta.' This revolutionary idea birthed quantum mechanics and laid the foundation for Bose's groundbreaking work. He stripped away the classical physics assumptions, synthesizing Einstein and Compton's hypotheses to derive a statistical property of radiation quanta—Planck's law was simply a manifestation of this statistical behavior.

Despite his sparse publications, Bose's impact resonates through the decades. His comet-like brilliance, though fleeting, illuminated a path for future physicists. As we mark a century since Bose's discoveries, we celebrate not just a moment in history but a legacy that continues to shape our understanding of the quantum world.

In the realm of quantum mechanics, Satyendra Nath Bose remains an eternal comet, his light guiding generations of physicists toward new horizons.

100

NEWS

Quantum Currents

January 26, 2024

Dignitaries trace the evolution of quantum mechanics on 100 years of S N Bose's colossal work

Distinguished scientists and scientific administrators, brought together on the occasion of the celebration of 100 years of the historic occasion when Satyendra Nath Bose authored the last of the four revolutionary publications that led to new quantum mechanics, traced the evolution of quantum mechanics through the years.

Prof. Ajay Sood, Principal Scientific Adviser to the Government of India, speaking at the inauguration of the 5-day long International Conference on Photonics, Quantum Information and Quantum Communication organised by the S N Bose National Centre for Basic Sciences (SNBNCBS) in Kolkata, pointed out that we are passing through the second revolution in Quantum Mechanics and that the gap between fundamental science and technological intervention is closing.

"A total of 750 million USD are being applied in four verticals. It is a wonderful time for all of us to be a part of this new mission. The right problems that are solvable and have wide applications will have to be addressed by researchers. Quantum sensing, satellite-based quantum communications and post quantum cryptography are some of the areas that need to be focused on," he added.

He stressed that 23 countries have set up National Quantum Missions and India has a substantial contribution to make at an international level, specially in the field of quantum algorithms.

> We are passing through the second revolution in Quantum Mechanics and the gap between fundamental science and technological intervention is closing.
>
> **Prof. Ajay Sood, PSA, GOI**

"After 100 years we are witnessing that the concepts of fundamental science are being deployed in a big way in areas of communication, computing, and other applications. With the National Quantum Mission (NQM) gathering steam, we have an opportunity to play at the global scale. The Mission will open the quantum science and technology domain for international collaboration. Four mission hubs will be set up across the country. Each hub is expected to bring together all technical experts in a consortium mode," Secretary, Department of Science and Technology (DST), Prof. Abhay Karandikar emphasised.

He added that the students and the experts could also make significant contributions to the NQM through ecosystem of startups that has developed in the country and through the four mission hubs to be established across the country to bring together all technical experts in a consortium mode to work on accelerating the working of the NQM.

He also highlighted the role of the Anusandhan National Research Foundation for creating a congenial atmosphere for research in the country.

This international conference is the first programme of the yearlong celebration of the 100 years of the historic occasion.

The yearlong celebration will include three International Conferences and several Outreach Programmes which SNBNCBS, an autonomous institution of DST, will be organizing throughout the year.

Prof. Tanusri Saha-Dasgupta, Director of S.N. Bose National Centre, said that Satyendranath Bose's seminal paper was published in 1924 after it was translated in German by Einstein. She added that scientists from different parts of the world and from different states of India, students and media persons are participating in the programme to exchange their views, share their research findings and draw inspiration from each other.

Satyendra Nath Bose's pioneering work on quantum statistics has paved the way for development of modern quantum technologies including Bose-Einstein condensation, quantum superconductivity, and quantum information theory. In 1924, Bose authored the last of the four revolutionary publications that led to the new quantum mechanics (the others being those of Planck in 1900, Einstein in 1905, and Niels Bohr in 1913). Half the fundamental particles in the Universe are named after him – BOSON. He derived Planck's law in a revolutionary way which impressed Einstein, and subsequently they continued to collaborate.

February 16, 2024

C-DAC Bengaluru and MIT Empower Faculty with Quantum Technology Insights

FDP @ Manipal Institute of Technology, Manipal

The Center of Development and Advanced Computing (C-DAC) in Bengaluru partnered with the Manipal Institute of Technology (MIT) Department of Computer Science and Engineering for a transformative five-day Faculty Development Program (FDP) hosted at Manipal from February 12 to February 16, 2024. The initiative, under the esteemed Manipal Academy of Higher Education (MAHE), aimed to equip faculty members with cutting-edge insights into quantum technologies.

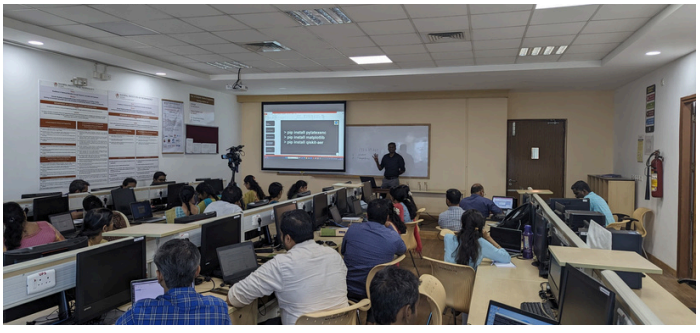
The inauguration ceremony, graced by Cdr. (Dr) Anil Rana, Director of MIT, marked the beginning of a journey towards technological empowerment. Dr. Asvija, Scientist 'F' at C-DAC Bengaluru, delivered an illuminating keynote address during the ceremony, highlighting the vast potential of quantum technologies in today's dynamic landscape.

Dr. Krishnamoorti Makkithaya, Head of the Department of Computer Science and Engineering at MIT, extended a warm welcome to guest experts and participants, fostering an environment conducive to collaborative learning and exploration.

Mr. Henry S., Scientist 'F' at C-DAC, led hands-on sessions focused on QSim and Qiskit Programming. His practical demonstrations and interactive workshops empowered attendees with the skills and tools required to navigate the complexities of quantum computing software, fostering a deeper technical acumen among the participants.

Mr. Raja Singh Yadav, Knowledge Associate at C-DAC, shared invaluable knowledge on quantum algorithms, including the Simon's algorithm and Shor's algorithms. Through engaging hands-on activities and theoretical explanations, he facilitated a thorough comprehension of algorithmic principles essential for quantum computing advancements.

Ms. Sahana Dermal, Project Engineer at C-DAC, provided in-depth insights into the Deutsch-Jozsa algorithm and Quantum Fourier Transform. Her expertise in these fundamental quantum computing concepts allowed participants to grasp the foundational aspects of quantum algorithms and their significance in computational processes.



Dr. Naresh Raghava, Senior Project Engineer at C-DAC, delved into advanced topics such as Grover's Algorithm, Quantum Communication Protocols, and Quantum Network Simulator. His sessions not only expanded participants' knowledge but also provided practical applications of these quantum concepts, enhancing their technical proficiency and problem-solving abilities.

Ms. Shikha Mehrotra, Scientist E at C-DAC, played a pivotal role in coordinating the FDP, ensuring its seamless execution and success.

The collaboration between C-DAC and MIT exemplifies a shared commitment to excellence in technological education and research, paving the way for a brighter and more innovative future in quantum technologies.

Source: C-DAC

Did You Know?

Quantum entanglement, a phenomenon where particles become interconnected and can influence each other instantaneously regardless of distance, is a fundamental concept in quantum physics and is being explored for applications in quantum communication and computing.

Quantum superposition allows quantum particles to exist in multiple states simultaneously, enabling the potential for quantum computers to perform specific complex calculations faster than classical computers.

February 20, 2024

Brainstorming session on pre-proposal call for NQM brings together researchers to create synergy in quantum research

The brainstorming session on the call for pre-proposals for setting up the Thematic Hubs (T-Hubs) under the National Quantum Mission (NQM) brought together quantum science researchers and quantum technologists from all over India who were keen to participate in India's historic National Quantum Mission.

Expressing his delight at the huge enthusiasm of researchers and technologists to participate in the brainstorming session, Secretary Department of Science and Technology (DST) Prof. Abhay Karandikar said,

"We have launched this mission with a goal that as we proceed,we will be making very definitive contributions to quantum technologies along with quantum science. Quantum science and quantum technologies cannot be separated. They must go hand in hand and will need a lot of synergy. This is the reason why the concept of hubs has been created. Under each hub, we will have technical groups which will be constituted with participation from more than one institute,"

Prof. Ajay Sood
PSA, GoI

"This is an ambitious project of the Government of India."

"We are making significant investments in this mission. A high -powered mission governing board will provide a broad direction to the entire mission and a mission technology research council will look into the execution aspects of this mission. We have invited call for proposals for setting up the T-hubs under this mission in the area of computing, communication, sensing, and devices in consortia mode".

"This brainstorming meeting will help bring awareness among researchers and foster synergy among the various technical groups. I hope this in person meeting will also be a networking event for all of you where you can interact with other researchers from other institutions and form a collaborative partnership which will be useful for submitting the proposals that we are looking forward to," he added.

The dignitaries interacted with 400 in-person and more than 150 online participants from institutions across the country to address their queries regarding the call for pre-proposals for setting up the T-Hubs.

The Department of Science and Technology (DST) will provide necessary resources for success of submission of pre-proposals and to facilitate researchers.

"I hope that we will be able to launch the research activities in this area which will not only make national impact but also a global impact. The NQM was started so that Indian researchers can take a leadership role globally, in quantum science and technology,"

Prof. Abhay Karandikar
Secretary
DST

The concept of working in consortia mode along with the industry is a unique experiment to ensure rapid outcomes of the Mission.

Dr. Akhilesh Gupta
Senior Adviser
DST

The NQM which is being implemented by DST will also work in collaboration with industry and startups to translate research to deployable technologies, so that India evolves to a competitive position at the international level in quantum science and technologies.

Source: PIB

March 5, 2024

C-DOT & PRL demonstrate integration of indigenous Fiber based Quantum Key Distribution system with Free Space QKD system leading to end quantum communication link in both Fiber and Free space as transport medium

C-DOT & PRL Achieve Significant Milestone: In a first in the country, both the organisations demonstrate integration of CDOT's indigenous Fiber based Quantum Key Distribution (QKD) system with Free Space QKD system from Physical Research Laboratory (PRL) leading to establishment of an end to end quantum communication link involving both Fiber and Free space as transport medium.

The end to end quantum communication link with C-DOT's Fibre-based QKD integrated with PRLs free space QKD was demonstrated to Prof. Ajay Sood, Principal Scientific Adviser to the Government of India and Dr Neeraj Mittal, Secretary Department of Telecommunications, Government of India during 2nd International Quantum Communication Conclave held at Vigyan Bhawan, New Delhi.

The rapid progress in quantum computers and quantum algorithms has put the security of the existing classical techniques of data security at risk as huge computational power of quantum computers can easily break the secrecy of the key used for encryption / decryption. The computational capacity of a quantum computer is expected to be million times faster compared to the most advanced classical computer available today. Although huge computing power is useful for solving many day-to-day issues and complex problems in various fields like financial, chemical, pharmaceutical, and automotive sectors, it will pose a threat to the security of the existing communication and data security infrastructure if any adversary gains access to quantum computers.

This imminent threat can be addressed by another new emerging branch of Quantum Technologies viz. Quantum Communications. One of the techniques of Quantum

Communications viz. Quantum Key Distribution (QKD) solves this problem and enables communication networks to ensure fool-proof security even in the presence of Quantum Computers. QKD will, thus, play a critical role in the country's economic development and has widespread applications in strategic sectors like defence, government communications, pharmaceutical and healthcare industries, financial services, data centres and telecommunication networks. QKD can be deployed through different mediums viz. optical fibre, free space as well as satellite to provide end to end security over the communication network.

Centre for Development of Telematics (C-DOT), telecom Research and Development (R&D) arm of Department of Telecommunications, has indigenously developed rugged & field deployable QKD solutions. CDOT is the first organisation in the country to have received Technology Approval from Telecom Engineering Center (TEC), a body under the Department of Telecommunications, Government of India. Notably, C-DOT's QKD link has been live between Sanchar Bhawan and NIC Headquarters (CGO Complex) since February last year.

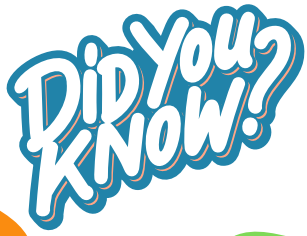
Physical Research Laboratory (PRL) is a 75 years old premier research institute under the Department of Space (DOS) and regarded as the cradle of space sciences in India. It has been working on utilizing space for quantum secure communication with support from the DOS and the Department of Science and Technology (DST). In the process of moving towards satellite-based quantum communication, it has already demonstrated free-space QKD with entangled photons and the effect of atmosphere on the secure key rate for 200 meters. Again, working with Space Application Centre (SAC), the institute was able to demonstrate end to end quantum encryption for 300 meters using indigenously developed entangled photon source.

Few years back, C-DOT and PRL had signed a MoU with an objective to cooperate in the development of Quantum Communication Technologies. As part of the same, C-DOT and PRL planned to integrate fiber based QKD system of C-DOT with PRL's free space QKD system. Now the same has been successfully completed providing an integrated solution to comprehensively address the needs of quantum secure communication networks, a landmark achievement in the niche area of Quantum Communication Technologies.

During the demonstration, Dr. Rajkumar Upadhyay, CEO, C-DOT said that it's a significant achievement for both CDOT and PRL and both the organisations will continue to work towards further scaling of the integrated QKD system.

C-DOT demonstrated the integrated quantum communication link with C-DOT's Fibre-based QKD integrated with PRLs free space QKD to Prof. Ajay Sood , PSA to Government of India and Dr. Neeraj Mittal, Secretary Department of Telecommunications.

Source: PIB



Free-Space QKD

In free-space QKD, quantum information is transmitted through open space, such as air or outer space.

Fiber-based QKD

Fiber-space QKD, on the other hand, relies on optical fibers to transmit quantum information securely over short to moderate distances.

March 23, 2024

Tech Horizons: A Conclave for Technocrats on Emerging Technologies

The Centre for Development of Advanced Computing (C-DAC) in Bengaluru recently hosted Tech Horizons, a groundbreaking conclave that brought together technocrats, industry leaders, and experts to delve into the realm of emerging technologies. Held from March 19 to March 23, 2024, the conclave focused on five interlinked technology areas: Quantum Computing, Internet of Things (IoT), Cybersecurity, High-Performance Computing (HPC), and Artificial Intelligence (AI).

The Quantum Technology track, which took place on March 19-20, showcased the forefront of quantum computing advancements. The track commenced with a Plenary session delivered by Prof. C. M. Chandrashekar from the Indian Institute of Science (IISc), setting the stage for deep discussions and insights into quantum computing's potential.

Mr. Henry Sukumar, Scientist F at C-DAC, delved into "Quantum Computing: A Revolution in the Making - Software & Simulators," highlighting the software tools and simulators essential for quantum computing development and experimentation. His session offered valuable insights into the software aspects driving quantum computing innovations.

Dr. Asvija, Scientist F at C-DAC, enlightened the audience with a session on "Quantum Computing: Understanding the Quantum Landscape - Hardware & Applications." His expertise provided a comprehensive overview of the hardware aspects and practical applications of quantum computing, shedding light on its transformative potential across industries.

Mr. Vaibhav Pratap Singh, Scientist D at C-DAC, shared insights on "Quantum Control Electronics," elucidating the critical role of control electronics in optimizing quantum computing systems' performance and reliability.

Tech Horizons: A Conclave for Technocrats on Emerging Technologies
Reflect. Refresh. Revolutionize.
Reshape the future of technology within your organisation
सी डैक
CDAC

Ms. Shikha Mehrotra, Scientist E at C-DAC, proceeded to exhibit C-DAC's Quantum Solutions, offering practical demonstrations of their quantum technology solutions and showcasing their real-world applications.

The track also included discussions on "Post Quantum Cryptography" by Mr. Raghavendra Patil, Scientist F at C-DAC, followed by Mr Jeevanjeet Dash, Knowledge Associate, explanation on their ongoing work and advancements in cryptography algorithms during the Quantum Technology track at Tech Horizons.

One of the highlights was the fireside chat on the integration of High-Performance Computing (HPC) with Quantum Computing, featuring Dr. Subodh Kulkarni, President & CEO of Rigetti Computing. Dr. Kulkarni's session provided a comprehensive overview of various quantum computing technologies, emphasizing their importance in solving applications based on the probabilistic model. He also underscored the critical need for integrating HPC with Quantum Computing to unlock new frontiers in computational capabilities.

The Quantum Technology track concluded with heartfelt thanks from Dr. Sudarsan, Executive Director at Bengaluru C-DAC, and the Quantum Technology track organizer Mr. Haribabu P. Their expressions of gratitude underscored the importance of collaboration and exploration in pushing the boundaries of Quantum Technologies.

Tech Horizons at C-DAC Bengaluru emerged as a platform that not only explored cutting-edge technologies but also paved the way for innovative solutions, partnerships, and knowledge exchange. The Quantum Technology track, in particular, provided attendees with a deep dive into various facets of quantum computing, enriching their understanding and readiness to embrace the transformative power of quantum technologies in diverse domains.

Source: C-DAC

March 23, 2024

Workshop on "Engineering and Integration Challenges in Quantum Communication and Quantum Computing"

C-DAC, Pune's Quantum Technology Group hosted a two-day workshop on "Engineering and Integration Challenges in Quantum Communication and Quantum Computing" on March 21-22nd, and an Industry networking day on March 23rd, 2024.

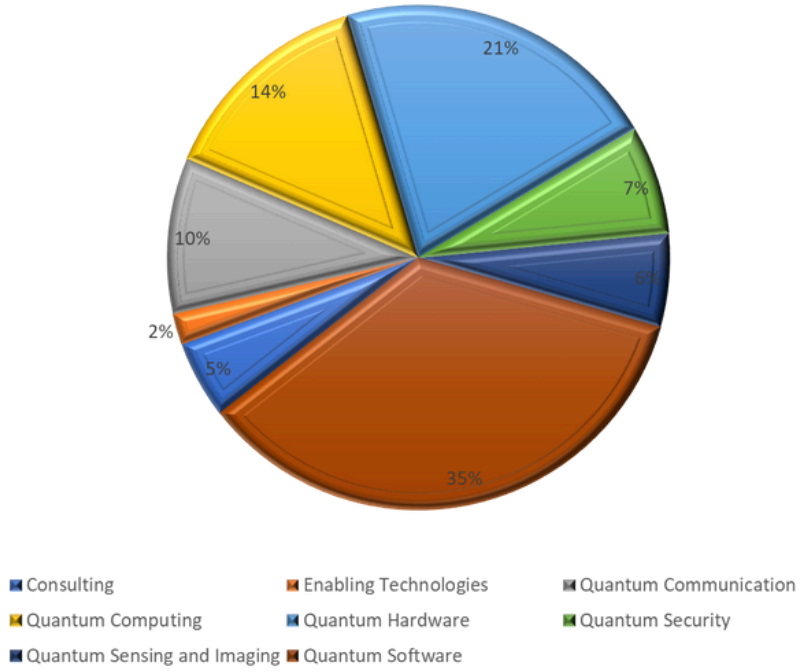
The workshop was inaugurated under the esteemed presence of Smt. Sunita Verma (Group Coordinator, R&D in IT, MeitY), Shri. Magesh Ethirajan (Director General, C-DAC), Col. A.K. Nath (Retd.) (Executive Director, C-DAC, Pune and Corporate Strategy) and Dr. S. D. Sudarsan (Executive Director, C-DAC, Bengaluru) at The Orchid Hotel Pune on March 21st, 2024.

This significant event marked a noteworthy convergence of key figures from both the Indian and global quantum ecosystems, facilitating a collaborative platform aimed at exploring the latest global developments in quantum computing and communication. The key focus areas of the workshop included, Free space quantum communication, Fiber-based quantum communication, Quantum Aerial Network, Quantum Key Distribution, Post Quantum Cryptography, Challenges in engineering and integrating quantum computers utilizing various quantum technologies, alongside hybrid quantum computing platforms. With an agenda packed with enlightening talks, tutorials and sessions. The sessions delivered by industry experts; participants were engaged in comprehensive discussions on a wide array of topics. These ranged from optical simulation techniques to intricate quantum circuit design, reflecting the workshop's commitment to fostering innovation and knowledge exchange.

This workshop emphasised the collaborative effort required to overcome the hurdles in quantum technology, focussed on indigenization of quantum technology products in communication and computing and delved into importance of testing and evaluation centre for quantum technologies.

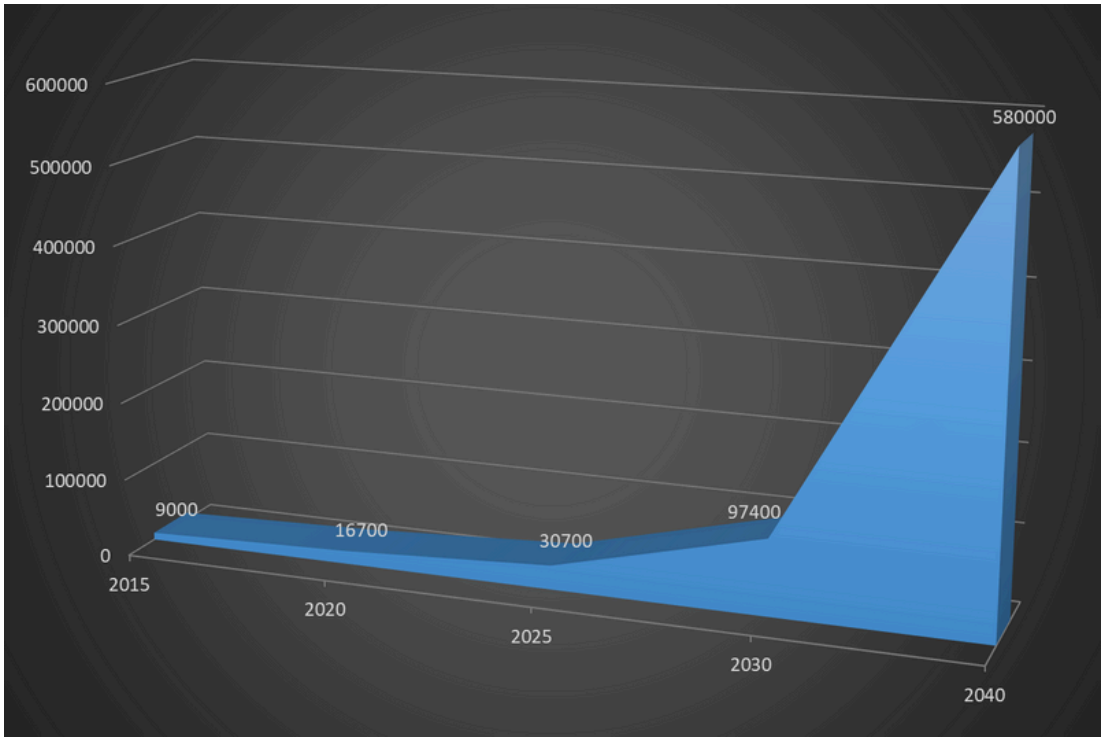
Source: C-DAC

Distribution of quantum companies per sector. Quantum computing indicates companies working on both hardware and software solutions.



Source : [1]

Estimation of the global number of jobs created for the quantum technologies market in the next two decades.



Source : [2]

[1],[2]:The Quantum Ecosystem and Its Future Workforce- Industry Report- 6/2020

PUBLICATIONS

List of selected publications in Quantum Technologies during January to March 2024

A survey on the complexity of learning quantum states.	*January 2024*	Nature Reviews Physics *Anshu, Anurag, and Srinivasan Arunachalam.*
Emergence of highly coherent two-level systems in a noisy and dense quantum network	*January 2024*	Nature Physics 1-7 *Beckert, A., M. Grimm, N. Wili, R. Tschaggelar, G. Jeschke, G. Matmon, S. Gerber, M. Müller, and Gabriel Aeppli.*
Logical quantum processor based on reconfigurable atom arrays	*February 2024*	Nature 626, no. 7997 *Bluvstein, Dolev, Simon J. Evered, Alexandra A. Geim, Sophie H. Li, Hengyun Zhou, Tom Manovitz, Sepehr Ebadi et al.*
Photonic Source of Heralded Greenberger-Horne-Zeilinger States	*February 2024*	Physical Review Letters, 132(13), 130604 *Cao, H., Hansen, L. M., Giorgino, F., Carosini, L., Zahálka, P., Zilk, F., ... & Walther, P*
Heralded three-photon entanglement from a single-photon source on a photonic chip	*March 2024*	Phys. Rev. Lett. 132, 130603 *Chen, S., Peng, L. C., Guo, Y. P., Gu, X. M., Ding, X., Liu, R. Z., ... & Pan, J. W.*
Demonstrating a long-coherence dual-rail erasure qubit using tunable transmons	*March 2024*	Phys. Rev. X 14, 011051 *Levine, H., Haim, A., Hung, J. S. C., Alidoust, N., Kalaee, M., DeLorenzo, L., ... & Painter, O.*

QuBIT Studio Launch @ C-DAC Bangalore

Quantum FDP @ Manipal Institute of Technology, Manipal (12-16 Feb 2024)

C-DAC product demonstration @

IISF 2023

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