QUANTUM

VIBES

A newsletter on
Indian Quantum Technology Activities

Quantum Algorithm
History, Expectations and Challenges
Prof. Anirban Pathak, JIIT

QUANTUM ALGORITHMS & APPLICATIONS

Global Quantum Computing Market

Q4 2023

Editor's Note

Welcome to the fourth edition of Quantum Vibes, where we delve into the captivating realm of "Quantum Algorithms and Applications." This edition promises a journey through the intricate history, evolving expectations, and the fascinating challenges within the quantum algorithm landscape.

We are delighted to announce the addition of Prof. Abhay Karandikar, Secretary of the Department of Science and Technology (DST), to our esteemed Advisory Board. His expertise will undoubtedly enrich the depth of insights we provide in this edition.

In a special feature, we introduce the "Voices of Quantummanians" section. This dedicated space invites the quantum community to share diverse perspectives, insights, and experiences. It's your platform to contribute, engage, and connect with fellow quantum enthusiasts. Explore the quantum community hub and let your voice resonate within the quantum tapestry.

In this edition, Prof. Anirban Pathak from JIIT shares profound insights on Quantum Algorithms—unraveling their historical roots, setting expectations, and addressing the challenges that lie ahead. His contribution promises to be a highlight in our exploration of this dynamic field.

As we navigate the intricate world of quantum algorithms, we invite you to join us on this intellectual exploration. Quantum Vibes continues to be your source of cutting-edge insights into the quantum technology landscape.

Happy reading!

DR. S.D SUDARSAN
Editor

MEET THE ADVISORY BOARD

We are delighted to welcome Prof. Abhay Karandikar to our Advisory Board, further enhancing the wealth of expertise guiding our Newsletter. Our Advisory Board comprises leaders and visionaries who bring diverse perspectives to help shape the future of our publication.

Prof. Abhay Karandikar currently serves as the Secretary of the Department of Science & Technology, India. Earlier, he served as the Director of IIT Kanpur from 2018-2023; he was the Dean (Faculty Affairs) and the Institute Chair Professor in the Department of Electrical Engineering at IIT Bombay. He has been instrumental in developing many path-breaking technologies and has been at the forefront of several large initiatives both at the institute and the national level. He is the founding member and chairman of the Telecom Standards Development Society of India (TSDSI), India's standards body for telecom. He has also served as the coordinator of Tata Teleservices IIT Bombay Center of Excellence in Telecommunications (TICET) and the National Center of Excellence in Technology for Internal Security.

Prof. Abhay Karandikar
Secretary, DST, India

Dr. Praveer Asthana
PSA, Fellow

Prof. Apoorva D. Patel
IISc. Bengaluru

Dr. Chandrashekar
IISc. Bengaluru
& IMSc. Chennai

Prof. Amlan Chakrabarti
University of Calcutta

Col. Asheet Kumar Nath
Executive Director,
C-DAC Corporate & Strategy

Quantum Algorithm:
History, Expectations and Challenges

1. ***A bit of basic ideas and history***

Many people associate algorithms with computers, but it's not correct. Algorithms were in existence since the early days of civilization and all of us have been exposed to algorithms in our childhood. To understand this point you need to note that algorithm is a systematic procedure to solve a problem and when we have been taught to add a 2 digit number with another 2 digit number, we had been taught a systematic procedure which says that write the unit place number of the second number below the unit place number of the first number and so on as shown in Figure 1.

Here we can see that to add two 2 digit numbers we need two steps (two additions), and to add two 3 digit numbers we need 3 steps. Similarly to add two n digit numbers we need n steps and that defines the complexity of the simple algorithm for addition. Just multiply a two digit number by another 2 digit number by the usual method taught in school and shown in Figure 1 and see that it requires 7 steps. Thus, multiplication is more complex task than addition as far as the algorithms taught in school days are concerned.

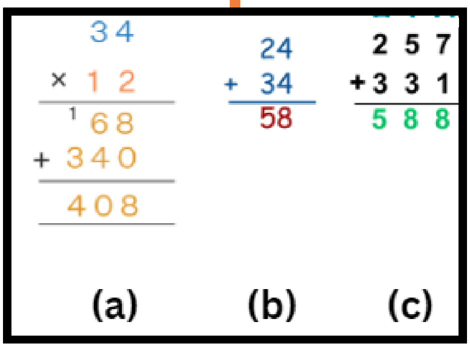


Figure 1: Computational task in
(a) - requires 7 steps
(b) - requires 2 steps
(c) - requires 3 steps

Figure 1:

Multiplication is computationally more complex than addition and we often realize that in our daily life.

Now, imagine that a student find a trick that can do the multiplication in 2 steps, instead of 7 steps, his trick will be considered as the new algorithm which is more efficient as it will be able to solve the computational problem (multiplication of two 2 digit numbers) in a faster manner. Exactly this is what quantum algorithms do, it provides speedup with respect to the corresponding classical algorithms. The speedup is achieved using quantum resources.

Historically, in 1985, first ever quantum algorithm was proposed by David Deutsch. He showed that whether a function f (x) having one bit domain and range is constant or balanced can be found by performing only one measurement (step) using quantum algorithm but it would require two steps in classical world. This can be understood easily by considering a coin, if both sides have the same symbol it represents a constant function, otherwise it represents a balanced function. To know whether both sides of the coin have same symbol or not, we have to see both sides or make two observations, but quantum mechanically one can perform a similar task by making a single observation. Subsequently, this algorithm was generalized by Jozsa to a situation where $x \in \{0, 1, 2, \cdots, 2^n - 1\}$, but $f(x) \in \{0, 1\}$. In addition, a promise is made that f (x) is constant or balanced. The computational task is to find whether f(x) is constant or balanced.

Quantum Algorithm:
History, Expectations and Challenges

Classically, we would require $2^{(n-1)} + 1$ observations, but Deutsch-Jozsa quantum algorithm can solve it by making one observation. High speedup achieved in Deutsch-Jozsa algorithm is due to the initial promise that reduces the number of queries to be made and it's important to find hidden problem structure (which can be stated as promise to reduce the number queries) in other problems to design new algorithms with the exponential speedup.

Interestingly, these two initial quantum algorithms established the advantage of quantum algorithms, but these algorithms don't have much practical applications. Later, in 1994, Peter Shor provided quantum algorithms for the factorization of odd bi-primes and discrete logarithm problems which established that RSA and Diffe Hellman schemes of cryptography will be vulnerable if a scalable quantum computer is built.

Shor's algorithm has a reasonable amount of classical part. Only quantum part is used for finding period of a specific type of function using quantum Fourier transform. In fact, Euclid's greatest common divisor finding algorithm which is known since 300 BC is also used in Shor's algorithm. Subsequently, Grover's algorithm for unsorted database search appeared in 1997.

These early algorithms provided a set of quantum primitives which are used in a large number of subsequent algorithms. Because of this fact, about 2 decades back Shor classified the quantum algorithms available at that time in 3 groups: Fourier transform based (like Shor's algorithm), Grover-type algorithm, and algorithms for simulating or solving problems in quantum physics. However, with due time, a good number of variational quantum algorithms (VQAs) and quantum machine learning (in most cases quantum assisted machine learning is more appropriate) algorithms appeared.

The journey is still continuing, but the enthusiasm is increased in the last 4 years with the repeated success in establishing quantum supremacy in solving Boson sampling problem using different hardware. Naturally, Shor's classification of quantum algorithms is not most appropriate now and we can classify existing quantum algorithms in various ways.

For our convenience based on the nature of tasks to be performed, we may classify them in following four groups:

(a) Search algorithms (like Grover's algorithm),
(b) Optimization algorithms,
(c) Prediction algorithms,
(d) Machine learning algorithms.

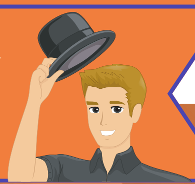
Of course they are different in the sense of applications and boundaries are not rigid. For example, unless you perform relevant data analysis using quantum machine learning algorithms, the power of prediction algorithms in quantum finance will not be able to provide the desired quantum advantage.

Did You Know?

The term "Algorithm" isn't a recent discovery; it's been weaving its way through history for about 900 years.

The word "algorithm" comes from the name of a mathematician and scientist, Muhammad al-Khwarizmi. He developed the concept of algorithms and is also credited with inventing algebra. The word "algorithm" is derived from his name. The term "algorithm" was imported into English, via French and Latin.

So, the next time you're in a numerical dance or untangling equations, take a moment to nod to Al-Khwarizmi. He's the unsung hero who set the stage for algorithms nearly a millennium ago!



2. Trust vs proof: Which kind of problems can be solved by quantum algorithms?

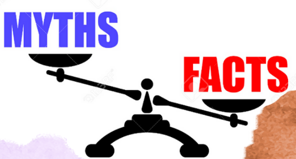
In computer science many things are believed which are not proved. We have trust on such conjectures, but there is no proof. For example, P≠NP is such a conjecture without proof. Similarly, at present it's believed that quantum computers can solve problems of BQP complexity class only, and there exist problems in NP which are outside BQP and the set of those problems leads to the idea of post-quantum cryptography that assumes that if we design a classical cryptographic protocol using one of those computational problems that cryptographic scheme will remain safe even if a scalable quantum computer is built. The trust on post quantum cryptography follows from the belief that quantum computers cannot solve any problem outside BQP. There is no proof and efforts should be made to design quantum algorithms for such problems. With the availability of a large number of cloud-based quantum computers, it's expected that a large no of quantum algorithms having various applications will appear in near future.

3. How much quantum are the present quantum algorithms?

All algorithms are not hardware specific, but some are. For example, we cannot run a quantum algorithm in a classical computer, and at present, while we are in noisy intermediate scale quantum (NISQ) era, we cannot extract full benefit of quantum computers. Naturally, while we are waiting for a fully quantum era (specifically “fault tolerant” era of quantum computing), we have designed several quantum-classical hybrid algorithms, where a part of the computational task is solved using a classical algorithm on a classical computer and remaining task is done using quantum algorithm.

With a guess (ansatz) like in variational method in quantum mechanics and involves quantum and classical devices. Say, a parametrized quantum circuit is to be run on the quantum device, but optimization of the parameters are done in a classical device.

In other words, the parameters of the VQA are trained using classical optimizer(s). Similarly, in variational quantum eigensolver (VQE), we can think of a quantum device computing an expectation value using the guess solution and a classical computer is improving the guess. VQEs and quantum approximate optimization algorithms (QAOAs) are special cases of VQA. There is specific reasons behind stressing on VQAs. Specifically, VQAs can be implemented in NISQ era and their adaptive nature is suitable to address the limitations of near-term quantum computers. Further, a wide range of applications (including but not restricted to solving a system of linear eqautions, obtaining the ground states of the molecules, and the simulation of the dynamics of various quantum systems) of VQAs have already been reported.



Myth
Quantum algorithms are simply faster versions of classical algorithms.

Fact
Quantum algorithms are fundamentally different from classical algorithms. They leverage quantum properties like superposition and entanglement to solve certain problems exponentially faster than classical counterparts. However, not all problems can be accelerated by quantum algorithms.

4. A few problems that interested readers can try to address

As indicated above, at present there exists a large number of quantum algorithms which can solve a wide range of problems at a speed higher than their classical counterparts, but the quantum primitives (e.g., quantum walk and quantum Fourier transform) used to construct these algorithms are only a few. There are reasons behind this, but without discussing those reasons, we may note that future research on finding new applications of these quantum primitives may yield interesting new algorithms.

Specifically, it may be interesting to try to design new quantum algorithms to solve computational problems like, graph coloring problem, ranking nodes in complex network, traveling salesman problem, satisfiability problem. Here, it may be noted that graph coloring problem is different from satisfiability problem, but the former can be reduced to the latter one. Algorithms can be designed to solve problems of many-body physics in order to solve dynamics and ground state problems of systems studied in high energy physics, quantum field theory (e.g., Lattice-Gauge theories) and quantum condensed matter physics.

Algorithms to simulate and understand dynamics in chemical complexes and biological systems are in very early stage, but it's very interesting to work on and collaborations between algorithm designers and scientists can be of great help. Similarly, it may be exciting to work on quantum machine learning algorithms with various applications (e.g., quantum image processing). One can also look at the possibility of the implementation of quantum algorithms in near-term and long-term quantum hardware with specific attention to device-specific algorithms.

It's important that in near future, we design algorithms with realistic assumptions about the capability of NISQ devices. In fact, in near future, one may try to demonstrate “quantum advantages” for practical use cases.

If failed in that effort, then to aim to theoretically investigate and understand the limitations of NISQ devices and subsequently to discover tools and techniques to obtain the best possible solutions using the limited quantum resources (such tools will be useful even in fault-tolerant era).

Though we are now in NISQ era, someday, we are hopeful to reach a fault-tolerant era. We should not stop designing algorithms with polynomial or super-polynomial speedup to be achieved in that era. Finally, we must attempt to solve problems outside QMA and BQP using quantum algorithms.

Unlike classical bits that are either 0 or 1, quantum bits, or qubits, exist in a superposition of both 0 and 1 simultaneously. This magical property enables quantum computers to explore numerous possibilities at once, potentially solving complex problems much faster than classical computers!

Did You Know?

Some Quantum Computers operate at extremely low temperatures, close to absolute zero (-273.15°C or -459.67°F), where the strange and powerful principles of quantum mechanics come into play. It's a computing world where being extremely cold is a key to unlocking extraordinary computational potential!

5. What kind of algorithms we are interested in?

The domain of quantum algorithms is vast and we don't work on all aspects of it. Our research activities are more focused on quantum cryptography, but we do work on certain aspects of quantum algorithm design and analysis. Specifically, we are interested in VQE, QAOA, distributed quantum computing, quantum classical hybrid algorithm for prime factorization which requires lesser amount of quantum resources (smaller size of the quantum register(s)) and quantum assisted machine learning for image processing with specific attention to optical character recognition.

Prof. Anirban Pathak

Prof. Anirban Pathak, currently serving as Professor & HoD of Department of Physics and Material Science & Engineering Department, JIIT. He earned his Ph.D. from Visva-Bharati, Santiniketan, India, and conducted post-doctoral research at Freie University, Berlin. Since joining JIIT, Noida in 2002, he has been actively involved in teaching and research, focusing on quantum optics and quantum information, particularly in quantum cryptography. As a Fellow of NASI, IETE, and OSI, he significantly contributes to academia. Prof. Pathak, a visiting scientist at Palacky University, Czech Republic, is also on the Editorial Board of Quantum Information Processing, Springer-Nature. Guided 6 Ph.D. students and numerous Post-Doctoral Fellows, he currently leads a research group focused on quantum optics and quantum information. Recognized with the 2017 Shri O. P. Bhasin Award, his impactful research extends to collaborative projects funded by DST, DRDO and other agencies, both in India and internationally.

Quantum Chuckles

Quantum tunnelling

A phenomenon that has no counterpart in classical physics, is the quantum-mechanical process by which a microscopic particle can transition through a potential barrier even when the energy of the incident particle is lower than the height of the potential barrier.

Quantum Tunnelling Commute:

"I wish quantum tunnelling worked for my daily commute. Imagine bypassing traffic by seamlessly passing through barriers to arrive at the office instantly."

QUANTUM EXPLORERS

MAPPING INDIA'S INNOVATORS IN QUANTUM ALGORITHMS

"Meet India's quantum pioneers in 'Quantum Explorers'. Discover how they're revolutionizing Quantum Algorithms & Applications, pushing quantum boundaries and shaping our future"

*** The list provided is not comprehensive and serves as a representative sample. Any omissions are unintentional. Please write to quantum-outreach-blr@cdac.in to include the information in our upcoming issues.*

QUANTUM EXPLORERS

Quantum Algorithms & Applications

Prof. Arun K Pati

IIIT, Hyderabad

Arun Kumar Pati is a highly accomplished professional, holding the position of Professor at the International Institute of Information Technology, Hyderabad. He earned his Ph.D. from the University of Bombay, Mumbai. Specializing in Quantum Computing, Quantum Information, and Quantum Technology.

Prof. Anirban Pathak

JIIT, Noida

Prof. Anirban Pathak, a distinguished theoretical physicist, currently serves as Professor & HOD at JIIT, Noida. With a Ph.D. from VisvaBharati, Santiniketan, and post-doctoral research at Freie University, Berlin, his expertise lies in quantum optics and information, specifically in quantum cryptography.

Prof. Amlan Chakrabarti

Calcutta University

Prof. Amlan Chakrabarti is a Professor and Director at the A.K.Choudhury School of Information Technology, University of Calcutta, and a Visiting Professor at IIIT Delhi. With 20+ years of experience, he is an esteemed researcher in Quantum Computing, specializing in Quantum Algorithms and Logic Synthesis.

Prof. Sugata Gangopadhyay

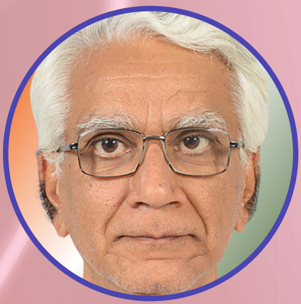
IIT Roorkee

Professor Gangopadhyay's primary research interest lies in Crptographic Boolean functions and their applications, design and analysis of stream ciphers, and exploring connections between Boolean functions and Quantum Computing.

Prof. Apoorva Patel

IISc Bangalore

Prof. Apoorva D. Patel is a professor at the Centre for High Energy Physics, Indian Institute of Science, Bangalore. He is notable for his work on quantum algorithms, and the application of information theory concepts to understand the structure of genetic languages.



Prof. Guruprasad Kar

ISI kolkata

Guruprasad Kar is a distinguished professional serving as the Professor and Head of the Physics and Applied Mathematics Unit at the Physics and Earth Sciences Division, Kolkata Headquarters. With a wealth of expertise, he contributes significantly to the academic and research landscape.

QUANTUM EXPLORERS

Quantum Algorithms & their Applications

Prof. P. Arumugam

IIT Roorkee

P. Arumugam is a Professor at IIT Roorkee, specializing in Theoretical Nuclear Physics, with research interests in hot and rotating nuclei, proton emission, neutron stars, radio astronomy, and quantum effects in few-body systems, including quantum computing applications.

Dr. Debanjan Bhowmik

IIT, Bombay

Debanjan Bhowmik, PhD, is affiliated with IIT Bombay, holding a doctorate from UC Berkeley. His expertise lies in Nanomagnetism and Spintronics, Neuromorphic Computing, and Quantum Machine Learning. He earned his BTech from IIT Kharagpur in 2010.

Dr. Shantanav Chakraborty

IIIT, Hyderabad

Shantanav Chakraborty is an Assistant Professor at the International Institute of Information Technology, Hyderabad. Holding a Ph.D. from the University of Lisbon, his research expertise spans Quantum Algorithms, Quantum Computation, and Quantum Walks.

Dr. Alok Shukla

Ahmedabad University

Alok Shukla is an Assistant Professor with a Ph.D. from the University of Oklahoma. His research focuses on Modular Forms, Automorphic Forms, Representations, and Quantum Computing.

Prof. Anil Shaji

IISER Thiruvananthapuram

A Professor of Physics at the Indian Institute of Science Education and Research, Thiruvananthapuram, specializing in Quantum Information Theory and Open Quantum Dynamics

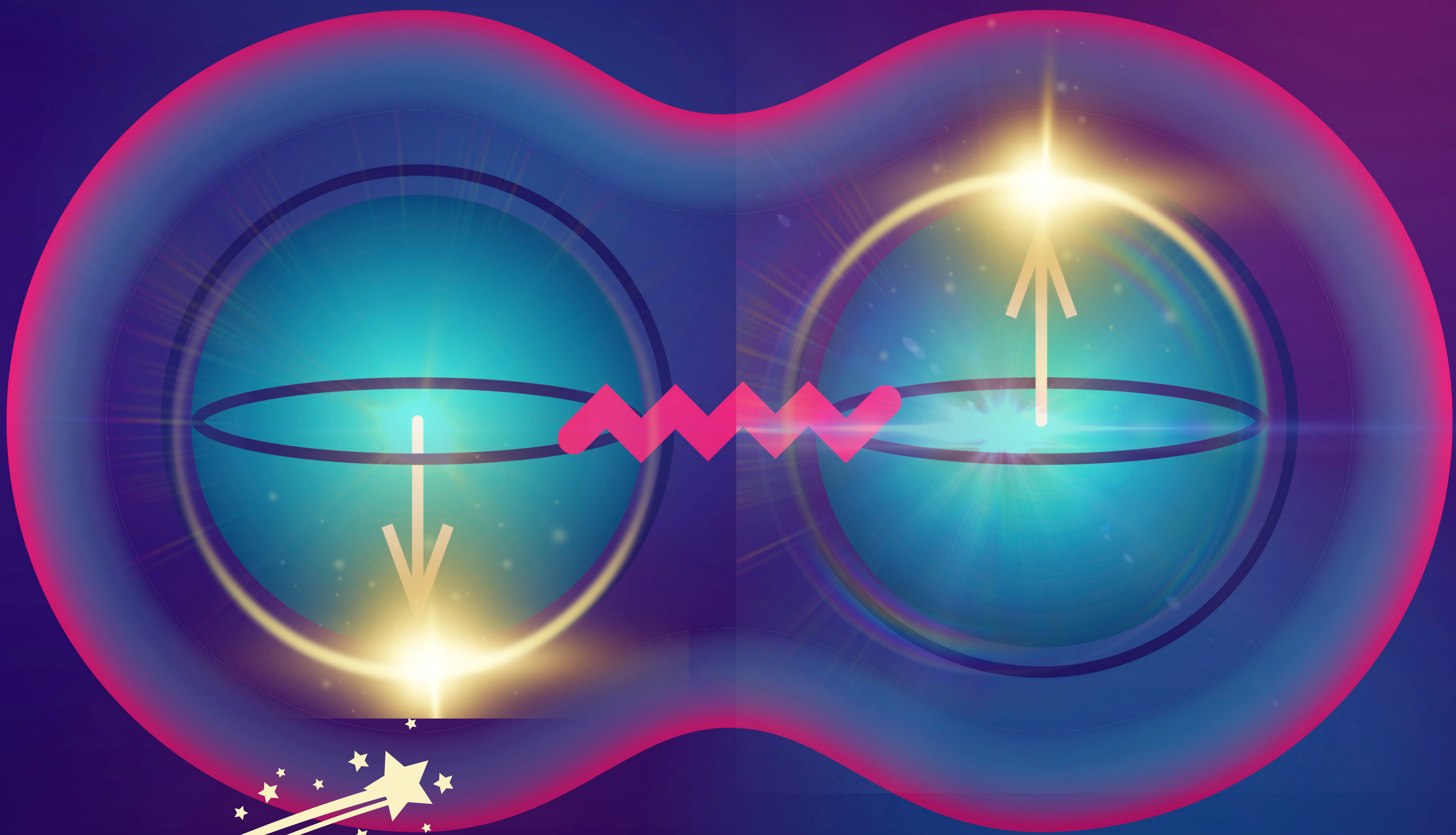
Dr. C. M. Chandrashekar

IISc Bangalore & IMSc, Chennai

C. M. 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.

Quantum Currents

News and Updates from the Quantum Universe



National Quantum Mission (NQM), approved recently by Prime Minister, will make India one of the Top Global leaders in areas like quantum computing, quantum communication, quantum sensing & metrology and quantum materials & devices

Dr. Jitendra Singh
Union Minister of State (Independent Charge) Science & Technology, MoS PMO, Personnel, Public Grievances, Pensions, Atomic Energy and Space
Mentioned during IQTC 2023

October 5, 2023

India Quantum Technology Conclave (IQTC) 2023 Unveils Strategies for Quantum Computing Integration

The Associated Chambers of Commerce and Industry of India (ASSOCHAM) successfully organized the 3rd Edition of the India Quantum Technology Conclave 2023 on October 5 in New Delhi. The conclave served as a pivotal platform for industry leaders, quantum experts, technology companies, research institutions, government agencies, quantum tech startups, and investors to converge and deliberate on the industrial roadmap, commercialization, and future strategies for integrating quantum computing technology into Indian industries.

The esteemed event witnessed the presence of eminent personalities, with Dr. Jitendra Singh, the Hon'ble Union Minister of State (Independent Charge) for Science and Technology, Government of India, gracing the occasion as the Chief Guest. Prof. Ajay Kumar Sood, the Principal Scientific Adviser, Government of India, also adorned the inaugural session as the Guest of Honour.

In his keynote address, Dr. Jitendra Singh emphasized the necessity for a collaborative relationship between the government, academia, and industry to propel the nation forward in the realm of quantum technology.

He underscored the importance of a global perspective, strategies, and parameters to address global challenges, urging the industry to actively engage in risk management.

The minister highlighted India's significant milestone as the seventh country with a dedicated quantum mission, joining the ranks of global leaders in quantum research and development. He expounded on the manifold benefits that the Quantum Mission would bring to sectors such as health, finance, and energy, along with applications in drug design, space exploration, banking, and security.

Furthermore, Dr. Jitendra Singh emphasized the quantum mission's alignment with national priorities like Digital India, Make in India, Skill India, Stand-up India, and the vision of a Self-reliant India. With its vibrant discussions and insights, the conclave will help propel India's quantum journey toward innovation, self-sufficiency, and global leadership.

Source: PIB

October 18, 2023

IBM Collaborates with MeitY to Propel Quantum Innovation in India

IBM has entered into significant Memoranda of Understanding (MoUs) with entities under India's Ministry of Electronics and Information Technology (MeitY). These MoUs are poised to drive innovation in quantum technology, artificial intelligence (AI), and semiconductors. The collaboration aims to contribute to India's overarching strategy for AI, fortify

efforts for self-reliance in semiconductor production, and advance the National Quantum Mission.

The MoUs have been formalized between IBM and key MeitY bodies, namely INDIAai, India Semiconductor Mission (ISM), and the Centre for Development of Advanced Computing (C-DAC). Rajeev Chandrasekhar, the Union Minister of State for Skill Development & Entrepreneurship and Electronics & IT, highlighted the transformative potential of semiconductors, AI, and quantum technologies in shaping the future. He underscored their significance for academic institutions, start-ups, and the broader innovation ecosystem in India.

As part of these collaborations, IBM is designated as a knowledge partner for the India Semiconductor Mission (ISM), contributing expertise to establish a semiconductor research center. The partnership encompasses sharing IBM's experience in intellectual property, tools, initiatives, and skills development. The focus will be on fostering innovation in semiconductor technologies, covering areas such as logic, advanced packaging, heterogeneous integration, and advanced chip design.

In alignment with the National Quantum Mission, IBM, under the MoU with C-DAC, will explore opportunities to advance quantum computing technology in India. The collaboration includes activities geared towards workforce enablement, industry and start-up development, research and development (R&D), and the creation of quantum services and infrastructure. The intent is to build competency in quantum computing applications aligned with national priorities.

Additionally, under the MoU with INDIAai, IBM will collaborate with the Digital India Corporation to establish a National AI Innovation Platform (AIIP). The AIIP will focus on AI skilling, ecosystem development, and integration of advanced foundation models and generative AI capabilities. Emphasizing the quantum aspect, the collaboration aims to support India's scientific, commercial, and human-capital development in quantum technology.

Sandip Patel, Managing Director, IBM India & South Asia, expressed IBM's commitment to being a trusted partner in enhancing India's innovation capabilities. The collaboration aligns with the government's efforts to build infrastructure, enhance human capital, and drive knowledge creation in quantum computing, AI, and semiconductors. This strategic partnership is integral to India's digital transformation and economic growth.

This collaboration reflects a significant stride toward positioning India at the forefront of quantum innovation and harnessing the transformative power of emerging technologies.

Source: Business Today

October 6, 2023

IIT Delhi Sets New Milestone in Quantum Communication: Achieves 380 km of Trusted-Node-Free Quantum Key Distribution

In a groundbreaking achievement, researchers at IIT Delhi, under the leadership of Dr. Bhaskar Kanseri, have successfully demonstrated trusted-node-free quantum key distribution (QKD) over an impressive distance of 380 km, utilizing standard telecom fiber. The team employed the Differential Phase Shift (DPS) QKD protocol, achieving a remarkable feat in the field of quantum communication.

The significance of this accomplishment lies in maintaining an exceptionally low quantum bit error rate (QBER), ensuring the security and reliability of quantum communication. The low QBER enhances the resilience of the DPS QKD scheme against various types of attacks, positioning it as a robust solution for securing financial transactions, protecting medical records, and safeguarding sensitive information. This breakthrough also holds promising implications for bolstering cybersecurity in network communication, including applications in the Internet of Things (IoT).

Dr. Kanseri highlighted that the current DPS QKD demonstration optimizes various error sources, including laser linewidth, modulation bandwidth, detector noise, and fiber dispersion. The result is an impressively low QBER (less than 2.5%), setting an international record for such a substantial distance in fiber.

It's worth noting that Dr. Kanseri's team, in collaboration with DRDO, had previously achieved the first Indian intercity quantum communication milestone between Vindhyanchal and Prayagraj in 2022, covering a distance of over 100 km using commercial-grade underground dark optical fiber.

Source: IITD

October 19, 2023

Samsung Semiconductor India Research Partners with IISc to Establish Quantum Technology Lab

In a pioneering initiative, Samsung Semiconductor India Research is joining forces with the prestigious Indian Institute of Science (IISc) to establish a cutting-edge quantum technology lab, as announced on Thursday.

Under the leadership of Mayank Shrivastava, an associate professor in the Department of Electronic Systems Engineering, the lab is poised to become a trailblazing facility dedicated to advancing quantum technologies. It is envisioned as a hub for technological innovation, workforce training, and collaboration with national and international quantum research institutions.

Samsung Semiconductor India Research and IISc have partnered to address reliability challenges in quantum technologies, focusing on integrating cryogenic control chips with qubits, photon sources, and detectors. The collaboration was formalized through a memorandum of understanding.

This collaboration signifies a strategic move to harness the collective expertise of Samsung Semiconductor India Research and IISc, propelling India's capabilities in the realm of quantum technologies.

Source: IISc

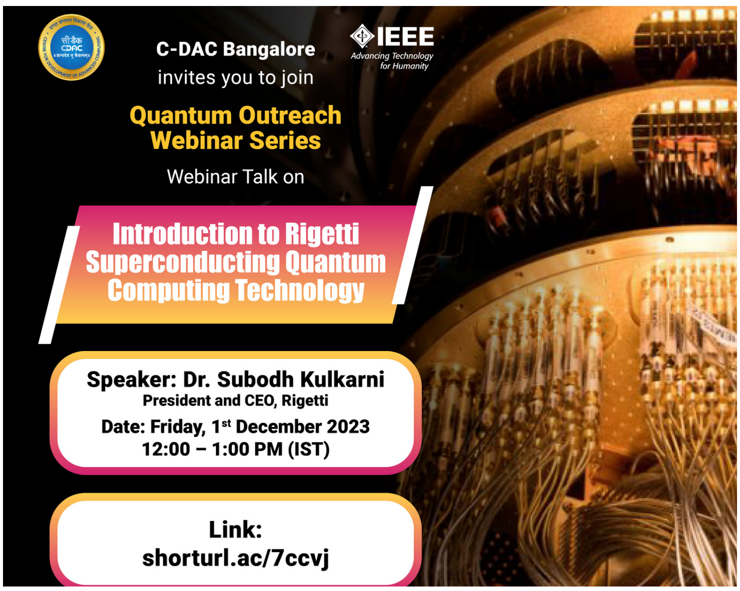
Dec 1st, 2023

C-DAC Bangalore's Quantum Outreach Webinar Series in Association with IEEE delivered by Dr. Subodh Kulkarni of Rigetti

This event, bringing together enthusiasts, professionals, and researchers, showcased C-DAC Bangalore's unwavering commitment to nurturing knowledge and collaboration in the quantum realm. Notably organized in association with IEEE, C-DAC's Quantum Outreach Webinar Series continues to be a pivotal platform for exploration and learning in the ever-evolving field of quantum technology.

C-DAC Bangalore recently elevated its Quantum Outreach Webinar Series with yet another enlightening session, featuring Dr. Subodh Kulkarni, President and CEO of Rigetti, as the esteemed keynote speaker.

Dr. Kulkarni, a distinguished authority in quantum computing, took center stage to demystify "Introduction to Rigetti Superconducting Quantum Computing Technology." His presentation not only highlighted the latest developments in quantum computing but also provided valuable insights into Rigetti's groundbreaking contributions.



Source: C-DAC

Nov 25th, 2023

Unveiling of Quantum Technology Lab at C-DAC

On November 25th, 2023, C-DAC Pune officially opened its Quantum Technology Lab, marking a significant milestone in India's quantum technology journey. Shri. S. Krishnan, Honorable Secretary of MeitY, presided over the inauguration ceremony, accompanied by esteemed guests including Shri. Ethirajan Magesh, Director General of C-DAC, and Col. Asheet Nath (Retd.), Executive Director of Corporate Strategy & C-DAC, Pune.

The Quantum Technology Lab at C-DAC Pune stands as the first of its kind within C-DAC, boasting a state-of-the-art clean room that facilitates experimentation on quantum technology devices in the realms of quantum communication and control electronics for quantum devices. The lab is equipped with high-specification equipment for testing and characterizing quantum communication and computing devices.

This groundbreaking initiative marks a pivotal step forward in India's quest to establish itself as a global leader in quantum technology, paving the way for transformative advancements in fields such as secure communication, drug discovery, and materials science.

Source: C-DAC

Dec 5-6, 2023

C-DAC Empowers Technological Frontiers with Quantum Accelerated Computing Workshop

C-DAC Pune organized a two-day "Workshop on Quantum Accelerated Computing" as part of the collaborative project "Quantum Accelerator". This project unites the expertise of C-DAC centers across Pune, Bengaluru, Noida, Patna, and Hyderabad, and is funded by MeitY (Ministry of Electronics and Information Technology). The workshop aimed to foster knowledge sharing, innovation, and collaboration within the rapidly evolving field of quantum computing.

C-DAC's commitment to fostering knowledge and innovation was evident throughout the workshop. Participants, ranging from tech enthusiasts to industry professionals, found the event instrumental in expanding their understanding of quantum acceleration computing.

Source: C-DAC

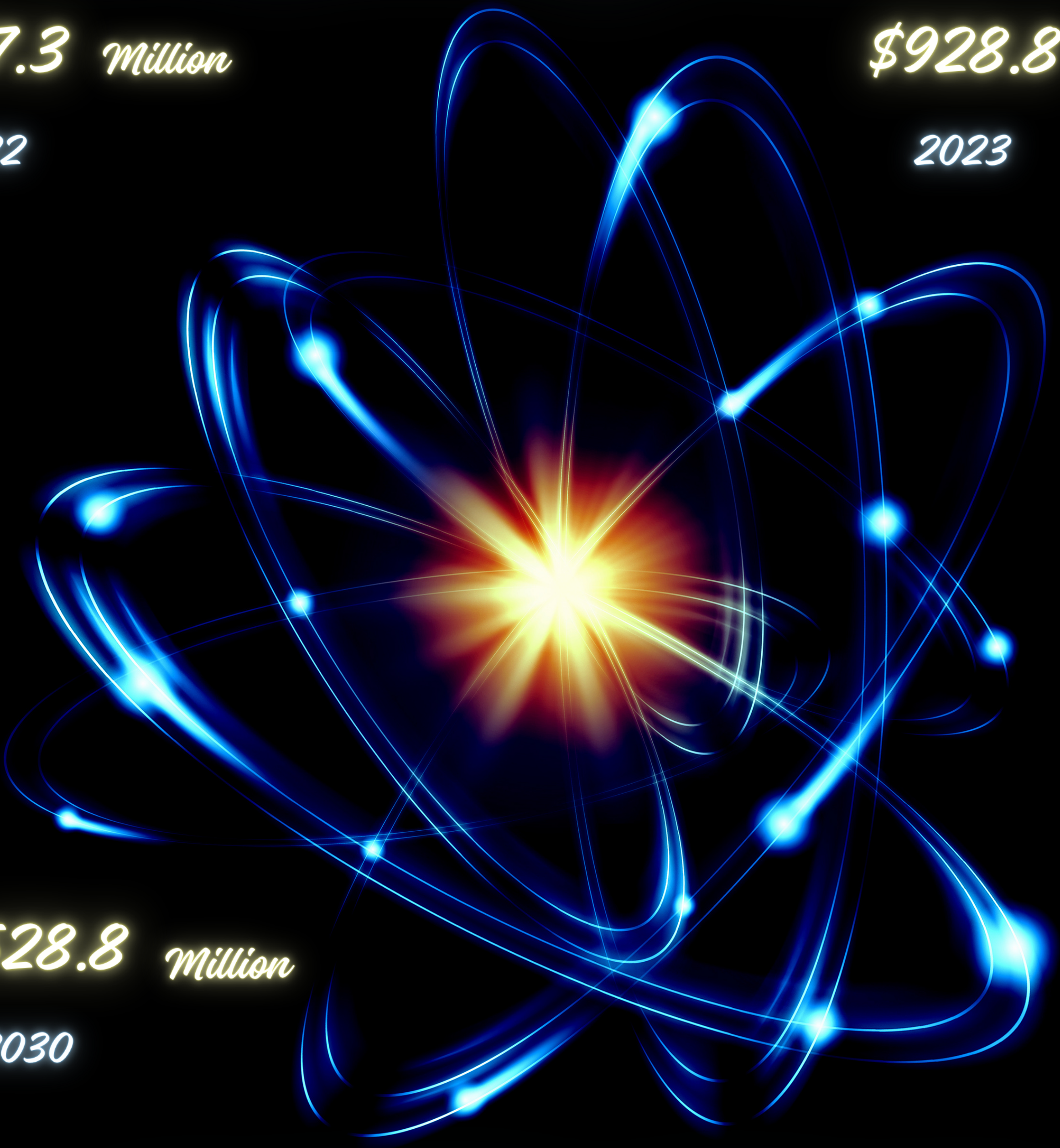
Quantum Computing Market

$717.3 Million

2022

$928.8 Million

2023



$6,528.8 Million

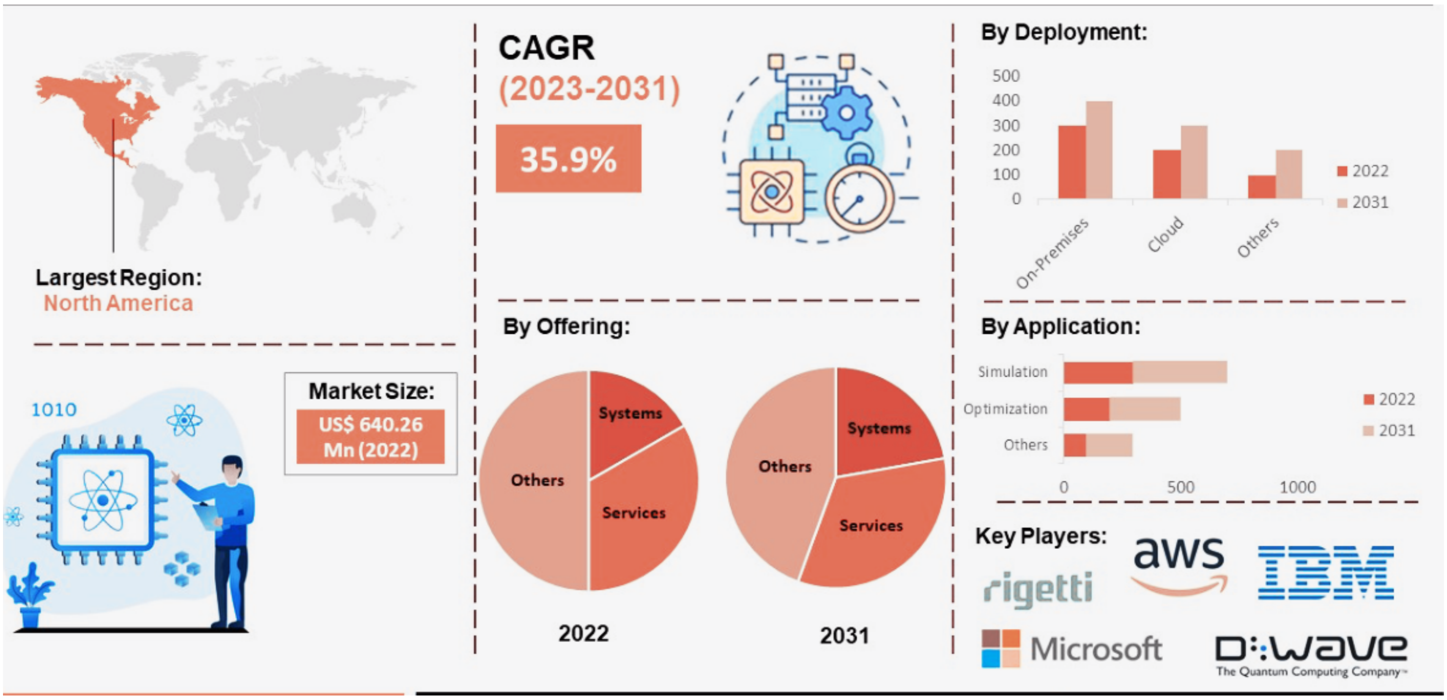
2030

CAGR 32.1%

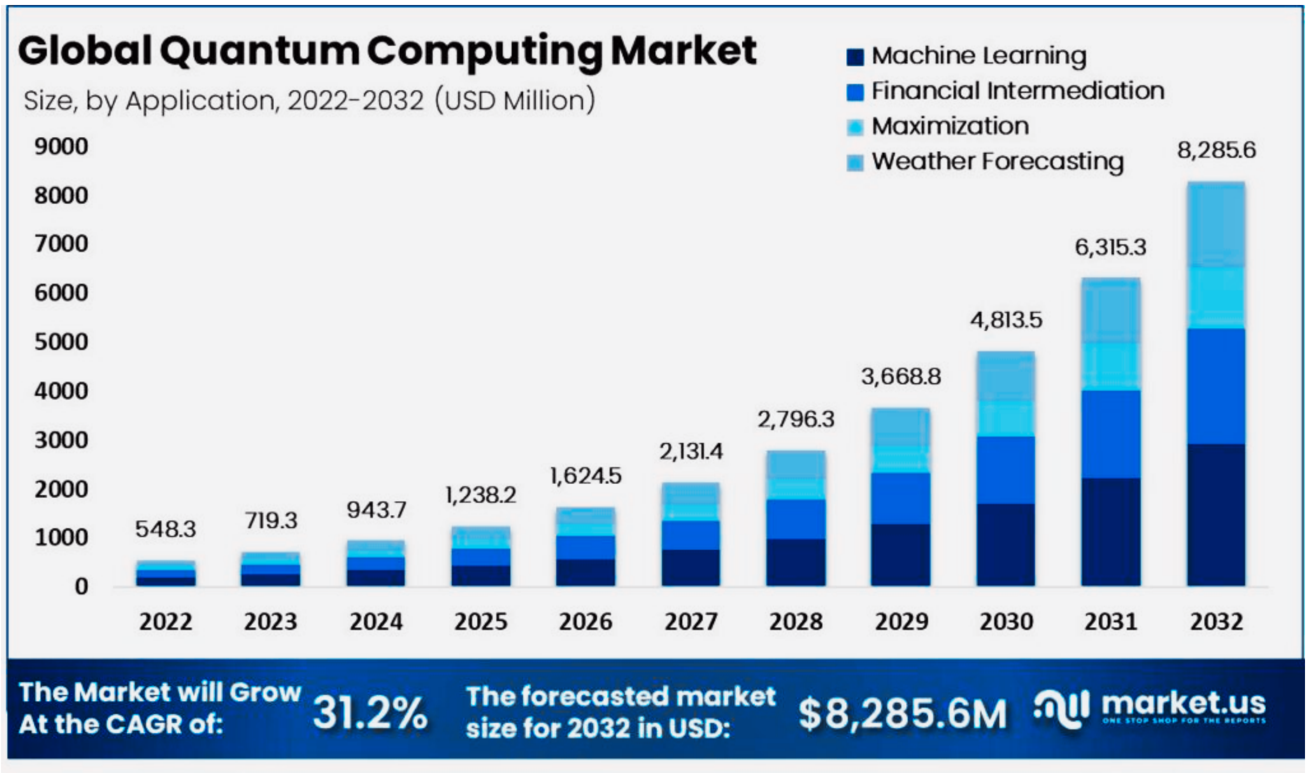
(2023-2030)

Source: Market Research Report, Fortune Business Insight Report ID: FBI 104855- July 2023

Global Quantum Computing Market Research Report



Source : [1]



Source : [2]

[1]: Global Quantum Computing Market Research Report ID: 2132 Oct 2023
[2]: Quantum Computing Market, market.us Report - November 2023

Voices of Quantumanians

Welcome to a dedicated space where the quantum community converges - "Voices of Quantomanias" in Quantum Vibes! This page is a vibrant tapestry of perspectives, insights, and experiences shared by quantum enthusiasts, professionals, and researchers alike.

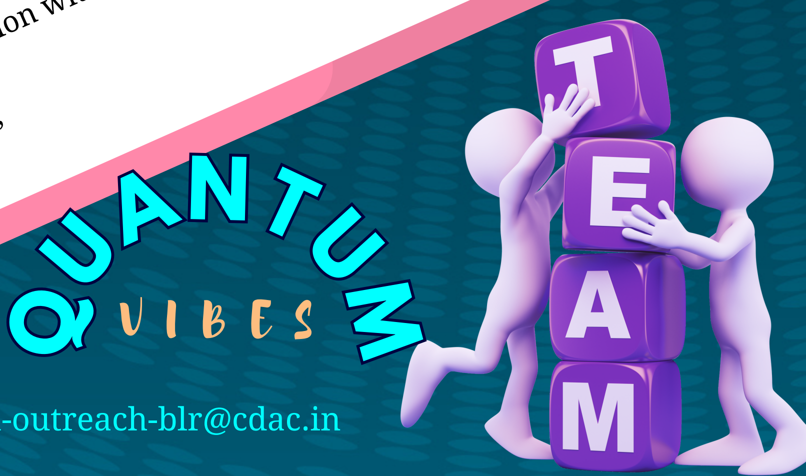
Explore Diverse Perspectives:
Dive into the minds of quantum visionaries, explorers, innovators, storytellers, and ethicists. Each voice contributes a unique hue to the ever-evolving canvas of quantum exploration.

Engage with the Quantum Community:
This is your space to connect, contribute, and engage with the quantum community. Whether you're a seasoned quantum professional or a curious enthusiast, here, every voice matters.

Share Your Quantum Journey:
Have a quantum story to tell? A perspective to share? This is the platform. "Voices of Quantumanians" is a dynamic space for you to contribute, fostering a community where quantum conversations thrive.

Join us on this quantum odyssey. Let the voices of Quantummanians resonate, creating a symphony of knowledge and passion within the pages of Quantum Vibes.

Quantumly Yours,



Share your views; write to us at quantum-outreach-blr@cdac.in

Voices of Quantumanians

IIT Ropar

As a reader of Quantum Vibes, I find each edition to be a captivating journey into the world of quantum wonders.

Rahul Dhankhar

IET Alwar

Delighted to contribute to 'Voices of Quantomania's'! I'm eager to share my experiences and insights with the quantum community. I'll be exploring quantum mysteries and providing fresh perspectives. Can't wait to be a part of this exciting journey!

Maruti Nandan

I am hoping that this magazine will serve as a platform to share thoughts in such ongoing and newer research areas in QC and also am curious about insights from experts in the field

Lakshmi Kalyani

C-DAC Noida

I'd love to see quizzes or short questions about quantum in future editions of Quantum Vibes.

Khin Zar Htun Kyi

University of Computer Studies (Taungoo)

IIT BHU

My little quantum journey started this year after attending a workshop by IISc-CDAC about basic quantum computing. Shortly after that, I got opportunity to attend another conference by CDAC on the recent advancement of quantum computing where I learnt about its use in optimization algorithm (like ant colony, GA and PSO have been modified for QC). From there onwards I am trying to create a team of students capable of quantum optimization.

Mayank Bajpai

C-DAC Noida

The Quantum Vibes is an excellent initiative, for people like me who though not having strong hold in the field, but having curiosity and keen interest, to work in the area [understood the difference between a Qubit and a BIT ; Working on QSim and QISKIT] after attending one-month Course on Quantum Computing using indigenous Quantum Simulator QSim [6th May2023-28th May 2023]

I would suggest , that domain specific pages may be introduced in the newsletter such as -QC for Cyber Security, QC for HealthCare, QC for IOT etc.

Lakshmi Kalyani

Share your views; write to us at quantum-outreach-blr@cdac.in

PUBLICATIONS

List of selected publications in Quantum Technologies during September to November 2023

Free-space and fiber-integrated measurement-device-independent quantum key distribution under high background noise *September 2023*	Physical Review Letters, 131(10), 100802 *Li, Y. H., Li, S. L., Hu, X. L., Jiang, C., Yu, Z. W., Li, W., ... & Pan, J. W.*
Phase encoded quantum key distribution up to 380 km in standard telecom grade fiber enabled by baseline error optimization *September 2023*	Scientific Reports, 13(1), 15868 *Pathak, N. K., Chaudhary, S., Sangeeta, & Kanseri, B.*
Error mitigation for quantum approximate optimization *September 2023*	Physical Review A, 108(3), 032408 *Weidinger, A., Mbeng, G. B., & Lechner, W.*
Optimal Generators for Quantum Sensing *October 2023*	Physical Review Letters, 131(15), 150802 *Reilly, J. T., Wilson, J. D., Jäger, S. B., Wilson, C., & Holland, M. J.*
Electron charge qubit with 0.1 millisecond coherence time *October 2023*	Nature Physics, 1-7 *Zhou, X., Li, X., Chen, Q., Koolstra, G., Yang, G., Dizdar, B., ... & Jin, D.*
Alignment between initial state and mixer improves QAOA performance for constrained optimization *November 2023*	npj Quantum Information, 9(1), 121 *He, Z., Shaydulin, R., Chakrabarti, S., Herman, D., Li, C., Sun, Y., & Pistoia, M.*

FUN FACT

Quantum Algorithms and Parallelism:

Quantum algorithms harness quantum parallelism, enabling them to explore multiple possibilities simultaneously. This unique feature accelerates certain problem-solving tasks.

Exploring large-scale entanglement in quantum simulation. *November 2023*	Nature, 1-6. *Joshi, M. K., Kokail, C., van Bijnen, R., Kranzl, F., Zache, T. V., Blatt, R., ... & Zoller, P*
Fault-tolerant qubit encoding using a spin-7/2 qudit. *December 2023*	Physical Review A, 108(6), 062403 *Lim, S., Liu, J., & Ardavan, A.*
Telecom band quantum dot technologies for long-distance quantum networks *December 2023*	Nat. Nanotechnol, 1-6 *Yu, Y., Liu, S., Lee, C. M., Michler, P., Reitzenstein, S., Srinivasan, K., ... & Liu, J*

Did You Know?

Quantum algorithms can break classical encryption:
Shor's algorithm, when applied to large numbers, can potentially crack widely used encryption methods like RSA. This fact is a driving force behind the need for post-quantum cryptography.

Quantum algorithms are the future of cryptography:
Quantum algorithms are paving the way for the future of cryptography. Unlike classical algorithms, quantum algorithms harness the unique principles of quantum mechanics to revolutionize the field of secure communication. The potential for faster and more robust encryption methods makes quantum cryptography a key player in the evolving landscape of data security.

Quantum Fourier Transform Magic:
Quantum algorithms, like the Quantum Fourier Transform, enable efficient manipulation of quantum states and form the backbone of many quantum computations.

Keep in touch

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