QUANTUM VIBES

A newsletter on
Indian Quantum Technology Activities

Quantum Sensing: Now and the Future

Prof. Kasturi Saha, IIT Bombay

Inside the Minds

Prof. Arindam Ghosh
IISc. Bangalore

The Power of Rydberg Atoms

Dr. Sanjukta Roy, RRI Bangalore

QUANTUM SENSING

Q3 2023

Editor's Note

"Unlocking the Invisible: Exploring the Quantum Realm's Secrets Through Sensing" - Explore the world of quantum sensing in this informative issue of Quantum Vibes.

Welcome to the third issue of Quantum Vibes, where we focus on the captivating realm of quantum sensing. With the current thematic issue, we are delighted to bring you a thought-provoking collection of articles, insights, and news that unravel the present and illuminate the future of quantum sensing.

It gives me immense pleasure to heartily welcome Dr. Praveer Asthana, PSA Fellow, O/o PSA to the Govt. of India, who has kindly agreed to guide us by joining as a member on the advisory board of our newsletter. With his valuable inputs, we are glad to introduce a new section titled 'Quantum Explorers', featuring leading researchers from different verticals of quantum technologies. I would also like to extend our welcome to Prof. Amlan Chakrabarty and Col. (Retd.) A.K Nath, for kindly agreeing to be on our Advisory board.

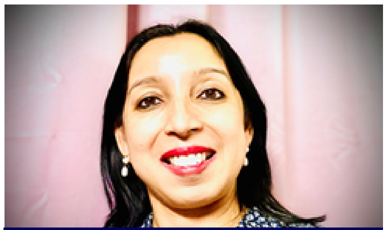
Exploring into the minds shaping quantum's future, we present an interview with Prof. Arindam Ghosh from the Indian Institute of Science Bangalore, in our "Inside the Minds" segment. Prof. Ghosh's insights provide a captivating glimpse into the visionary world of quantum materials research.

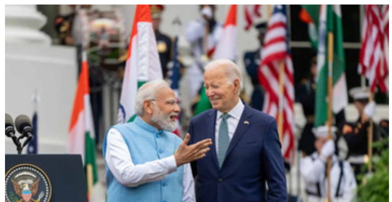
In "Quantum Sensing: Now and the Future," the newsletter features an article from Prof. Kasturi Saha from the Indian Institute of Technology Bombay. Prof. Saha navigates the current landscape of quantum sensing, revealing its impact across domains from precision measurement to quantum-enhanced technologies.

Dr. Sanjukta Roy from the Raman Research Institute, unveils the remarkable capabilities of Rydberg atoms, showcasing the seamless interplay between theory and experimentation in her article titled "Quantum Sensing Unveiled: The Power of Rydberg Atoms."

Of particular significance, the current edition coincides with the announcement of the Indo-U.S. joint Quantum Coordination Mechanism, aimed at strengthening quantum technology research and AI development nationwide. With this important initiative geared towards facilitating collaboration between industry, academia, and government within the realm of quantum technology, I am confident that research in India will gain fresh momentum and foster innovation in the days ahead.

DR. S.D SUDARSAN
Editor





MEET THE ADVISORY BOARD

Dr. Praveer Asthana is a PSA Fellow with a background in Theoretical Particle Physics from the University of Alberta, Canada. He served at the Department of Science and Technology (DST) for over three decades, holding various positions, including Senior Scientific Officer and Adviser/Scientist-G. He played a crucial role in leading and establishing significant initiatives, such as Science and Engineering Research Board (SERB) and Nano Mission. He also contributed to India's participation in international and national mega science projects.

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. His major field of work has been the theory of quantum chromodynamics, where he has used lattice gauge theory techniques to investigate spectral properties, phase transitions, and matrix elements.

Col. Asheet Kumar Nath is an accomplished professional with extensive experience in R&D and corporate affairs. He is currently serving as the Executive Director of Corporate Strategy and C-DAC Pune. He is also the Chairman of the Academic Council at C-DAC. Col. Nath has been associated with C-DAC for over a decade and has coordinated R&D activities of all centers under C-DAC. Prior to joining C-DAC, Col. Nath served in the Indian Army for 25 years.

Dr. Chandrashekar leads a research group at IMSc focusing on theoretical aspects of quantum information, quantum simulation, and computation. They develop quantum algorithms and protocols for near-term quantum hardware, quantum communication, and quantum network dynamics. 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.

Prof. Amlan Chakrabarti is a Full 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. He has received several prestigious awards, including the Erasmus Mundus Leaders Award and the Hamied Visiting Professorship from the University of Cambridge.

Quantum Sensing Now and the Future

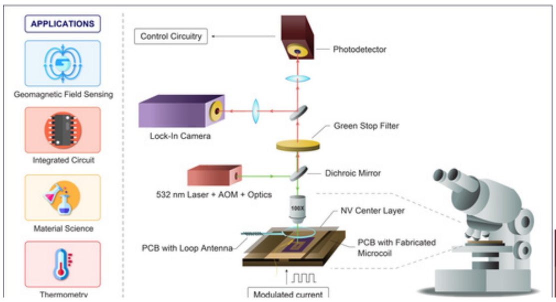
Quantum sensing and its challenges

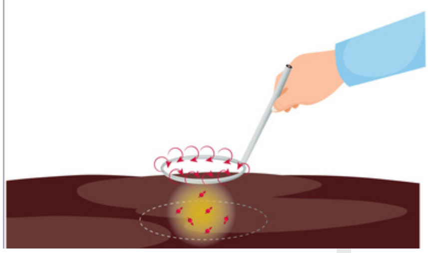
Quantum sensors use quantum coherence and the entanglement of atoms and light, making them highly sensitive to the environment. They are essential to the creation of metrological instruments because they are capable of more precise quantification than any of their classical counterparts of magnetic field, rotation, gravity, acceleration, and the passage of time. They can be used to create portable navigation systems, atomic clocks and cameras that can see through obstacles. They can also be used to create devices that map underground structures, among many other uses that have the potential to revolutionize industries like transportation, agriculture, energy and as well as the fields of security, medical diagnostics, and finance. However, their commercial and industrial promises need to be realized. Gaining funds and attention to modify quantum sensors for use in practical contexts is not without challenges, though.

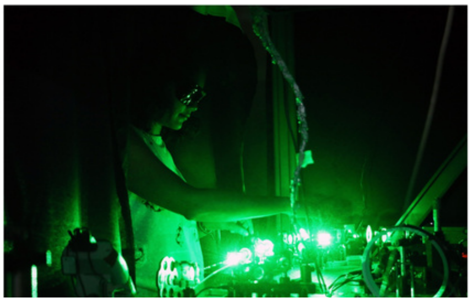
However, government-industry-academia-led partnerships will pave the way for realistic applications that can truly leapfrog lab-scale prototypes of today into near-term useful solutions.

Quantum sensing in Pquest Lab

We, at the Pquest Lab in IIT Bombay, develop quantum sensors based on nitrogen-vacancy (NV) centers in diamond for magnetometry and magnetic field imaging. The next frontier in high-performance biosensors for diagnostic systems is the







As researchers developing quantum sensors in academic settings, we are keen to make the government and industry aware of possible benefits, in particular, the development and indigenization of vital national infrastructure. A critical challenge is that it is hard to predict exactly how and where emerging technologies will be adopted. Making the case for change is probably the hardest obstacle for quantum sensing, as it is for any new technology. The technology's popularity is limited, at least momentarily, by the high upfront expenditures, high operational costs, and uncertain performance gains.

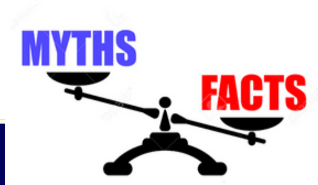
detection of target biomolecules in ultra-low concentrations at few or single molecule resolution. Detecting ultra-low concentrations of biomarkers(proteins) of diseases such as neurodegenerative diseases, cardiovascular diseases, and cancer or antibodies of highly contagious diseases is necessary for early detection and therapeutic interventions.

Moreover, direct structural analysis of infectious proteins at the atomic level can unravel their functionality in physiological and pathological processes. Keeping these goals in mind, we are developing tools based on NV centers in diamond that can be used for performing nano-MRI and quantum sensors for medical diagnostics and the investigation of quantum materials. Further, to enhance the sensitivity of the magnetometer, we are also looking to develop quantum-enhanced protocols based on light-matter interactions. Analogous to an optical microscope, we are the first lab in the country to have developed a quantum diamond microscope for imaging temporally varying magnetic fields with a spatial resolution of a micron. This method can be used to find flaws in semiconductor chips in addition to being effective for imaging the brain. We have also been pushing towards developing portable magnetometers leveraging on the solid-state platform and room temperature operations. A greater goal will be to form a hybrid network of sensors leveraging the sensitivity of atomic magnetometers and the spatial resolution of NV center magnetometers.

Quantum sensing and its challenges

There are many different types of quantum sensors. Most prominent electric and magnetic sensors are based on atomic vapours, superconducting circuits, and NV centers. While NV centers are solid-state and room temperature-based sensors, atomic sensors are in the gas phase and often best applied at cryogenic temperatures. Similarly, superconducting circuit-based sensors are only operational at cryogenic temperatures. These sensors could potentially be used for communication interception and stealth detection in the strategic domain. In the commercial domain, such sensors leverage the quantum advantage of solid state and atomic sensors, finding use in structural health monitoring, brain imaging, and the detection of magnetic spectroscopy for medical applications, enhancing diagnostic accuracy. Similarly, NV centers, atomic vapour devices, and superconducting quantum interference devices (SQUIDs) also find application in gravimetry and gradiometry. Monitoring subsurface geophysical phenomena such as geothermal reservoirs requires the use of gravimeters, which measure the strength of a gravitational field, and gradiometers, which measure variations in a gravitational field.

Quantum gravimeters and gradiometers can improve the accuracy of locating subterranean resources such as minerals and oil by detecting minute changes in the local gravity and anomalies in the earth's magnetic field. Additionally, these sensors can also be employed for inertial navigation. Quantum imaging via quantum radars can be applied for enhanced detection and localization of objects with higher resolution, finding applications in border surveillance and other strategic operations. These technologies can also be used to improve the assessment of environmental parameters in airplanes and naval ships. They are sometimes coupled with sonar to locate submarines.



Myth :

Quantum sensing is only beneficial in extreme conditions like space or extreme temperatures.

Fact :

While quantum sensors do excel in extreme conditions, they also offer enhanced sensitivity and precision in everyday situations, providing advantages in various applications, including medical diagnostics and environmental monitoring.

The path forward

Another frontier of quantum technologies can be reached by combining the strengths of quantum sensing, quantum communication, and quantum computation to form a network of quantum sensors. Advances in the domains of machine learning, AI and the internet of things in combination with quantum sensing can potentially lead to applications in traffic optimization, fraud detection, weather forecasting, and drug discovery. Akin to the invention of the laser, which is a classic example of "solution seeks a problem", many of the quantum sensors of the modern era are solutions awaiting translation and commercialization for suitable problems.

Over the course of the history of physics, there have been numerous serendipitous discoveries. For instance, X-rays that are today critical and essential technology for medical diagnostics and airport security, was a byproduct of research to determine if electron beams could pass through glass. The technological revolution that started during the Second World War, followed by the initial wave of invention, made it possible to commercialize crucial technologies like MRI machines, IR cameras, radars, transistors and telecommunication systems, to name a few.

Likewise, as seen by the rise in start-ups in this industry, quantum sensors are moving from the lab to the real world. The atomic length scale of quantum sensors and their coherence properties enable unprecedented levels of spatial sensitivity and precision. Although it may be difficult to predict their immediate impact, these quantum technologies may be valuable for a range of applications in the future. Initiatives are needed to bring businesses, from component manufacturers to system integrators, together with academics to aid in finding commercial solutions, as opposed to simply inventing the technology and then scaling up production in the hopes that there would be a market. There is an urgent need for a long-term, industry-led strategy in collaboration with academia for the development of quantum sensors. Blue-sky research, however, is essential for the technology of the future and must be done at the same time.

Prof. Kasturi Saha

Kasturi Saha is associated with the Department of Electrical Engineering at IIT Bombay. She was a postdoctoral fellow in Prof. Paola Cappellaro's group in the Research Laboratory of Electronics at the Massachusetts Institute of Technology. She obtained her Ph.D. from Prof. Alexander Gaeta's group in the School of Applied and Engineering Physics at Cornell University. Prior to that she did her M.Sc. from IIT-Delhi and B.Sc.(Hons.) from St. Stephen's College, Delhi. Her research interests include quantum sensing, nano-photonics, precision metrology, and quantum computation with solid-state color defects. She is a recipient of the Department of Science and Technology-INSPIRE faculty fellowship, IIT Bombay Young Faculty Award, and the Venus International Young Faculty Award.

https://www.ee.iitb.ac.in/web/people/kasturi-saha/

Quantum Sensing Unveiled: The Power of Rydberg Atoms

Quantum sensors utilize basic principles of quantum mechanics to precisely measure a physical quantity. Quantum sensing can lead to highly sensitive measuring devices with unprecedented accuracy far exceeding that of traditional sensing devices. In recent times, Quantum sensing has become a unique field of research progressing at a fast pace in the area of Quantum Technology. Quantum sensing provides promising possibilities for high sensitivity and precision in measurements with widespread applications.

Quantum sensors have diverse applications such as medical imaging with quantum magnetic sensors, space exploration, geophysics, mineral extraction, and agriculture. Quantum sensors for gravity and gas detection installed on satellites could collect accurate data on groundwater levels, volcanic eruptions, carbon dioxide, and methane to improve the modeling of climate change. Combinations of quantum sensors measuring gravity gradients, magnetic fields, and inertial forces are a thousand times more precise than their classical counterparts and enable reliable navigation in places where satellite signals are unreachable such as remote geographical regions, conflict zones, or deep underwater regions.

Quantum radar sensor utilizes quantum entangled microwaves to detect objects at room temperature with low light-reflectivity which may be useful for Defence applications such as improved radar systems and security scanners.

While quantum computers might be decades away from offering widespread practical applications, Quantum sensors are widely being used in contemporary experiments in the Lab and have significant practical applications. Quantum sensors such as Atomic clocks measure time very accurately using quantum transitions in atoms with high resonance frequencies. The accuracy of the atomic clocks maintains the synchronization of communication networks and is crucial for satellite navigation services such as Global Positioning System (GPS).

We, at the Quantum Optics with Rydberg Atoms Lab (QuORAL) at RRI, Bangalore develop quantum sensors with Rydberg atoms. Quantum sensors are quantum systems with discrete energy levels that can be coherently controlled and interact with external fields such as electric and magnetic fields with sensitivity far exceeding their classical counterparts. They utilize quantum entanglement, quantum superposition, quantum interference, and squeezed states to enhance sensitivity and surpass the performance of classical sensors. Measurements using Quantum sensing comprise three essential steps such as

- initialization of the quantum sensor
- interaction of the quantum sensor with the physical quantity of interest such as electric or magnetic fields,
- readout of the final state.

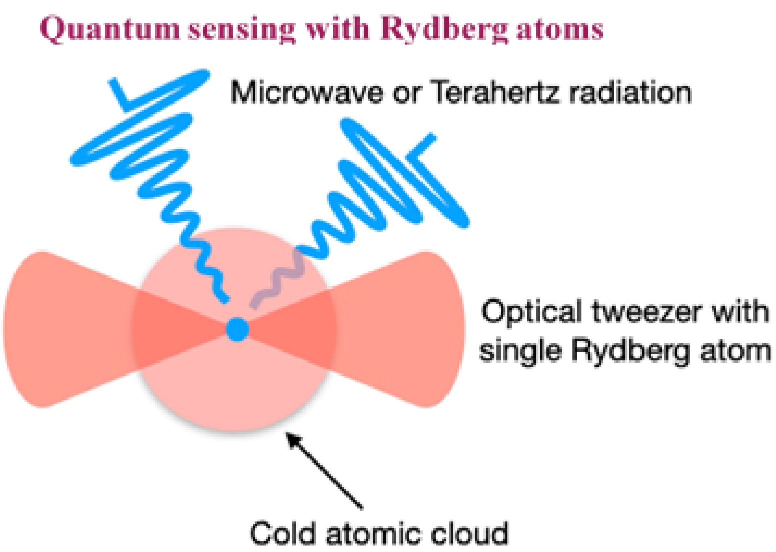
DID YOU KNOW?

Quantum radar
has the potential to detect objects that are specifically designed to be invisible to traditional radar systems. This opens up new possibilities for stealthy operations and improved security.

Quantum sensing can be performed using a wide variety of quantum systems such as neutral atoms in the ground state, Rydberg atoms, atomic clocks, trapped ions, solid state spins such as Nuclear Magnetic Resonance (NMR) sensors, Nitrogen-Vacancy (NV) centres, semiconductor Quantum dots, Superconducting circuits such as SQUID and Superconducting qubits, Elementary particle sensors such as Muons and neutrons, single electron transistors and photonics sensors.

Quantum sensing using Rydberg atoms:

The polarizabilities of highly excited Rydberg atoms scale as n^7 where n is the principal quantum number of the atomic energy level, making it highly sensitive to external DC or AC electric fields. Atomic systems are stable quantum systems that offer the most accurate and versatile platforms for Quantum sensing. Unlike the traditional sensors, whose accuracy depends on the calibration of the probe, atoms can be used to make self-calibrated precise sensors since atoms of the same isotopic species have identical properties irrespective of their geographical location and do not have limitations such as manufacturing variations and ageing like human-fabricated sensors.



A single Rydberg atom in an optical tweezer is an excellent Quantum sensor whose sensitivity to electric and magnetic fields can surpass the state-of-the-art precision levels achieved with traditional sensing devices.

Quantum sensing using Rydberg atoms:

If the uncertainty is distributed equally between the conjugate variables then the measurement precision is limited by the Standard Quantum Limit (SQL) which prevents the measurement precision to reach the Heisenberg Limit. However, by using non-classical states

FUN FACT

Ultra-Slow Motion:

In the laboratory, scientists can put Rydberg atoms into a quantum slow dance. By cooling them down to ultra-cold temperatures, these atoms move at an almost snail's pace. This quirky technique lets researchers study their dance moves with extraordinary detail, revealing hidden quantum secrets. It's like watching an atomic ballet in super slow motion, unlocking mysteries that could revolutionize technology and our understanding of the quantum world.

such as ‘Squeezed states’ of Rydberg atoms, the Standard Quantum limit can be overcome and the Heisenberg limit can be achieved. This can have promising applications in Quantum Metrology as well as the detection of single electrons in mesoscopic devices. Injection of squeezed light into interferometers enables higher sensitivity of the interferometers to weak signals that would otherwise not be possible to be detected classically. This led to an important practical application of quantum sensing for the detection of gravitational waves. Gravitational wave detectors such as LIGO measure weak gravitational wave signals below the Standard Quantum Limit using squeezed light. Squeezed light has also been used to detect signals below the standard quantum limit in plasmonic sensors as well as in atomic force microscopy.

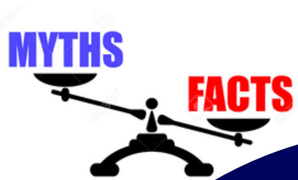
For widespread commercial applications of Quantum sensors, it is important for the researchers to collaborate with the Industry to make their Quantum sensors field-deployable with modifications in their setup such as compactification as well as making the sensor robust against decoherence due to ambient stray fields and extreme climatic conditions. This would enable the masses to access and take advantage of the far-reaching applications of versatile and accurate quantum sensors.

Dr. Sanjukta Roy

Dr. Sanjukta Roy is a Scientist (Principal Investigator) at Raman Research Institute. Her research is focused on Quantum Technologies using ultra-cold Rydberg atoms, Quantum Simulation with ultra-cold Quantum Mixtures in optical potentials, Spin correlation spectroscopy and Few-body physics. She obtained her PhD from the Tata Institute of Fundamental Research, Mumbai, where she realised India's first Bose-Einstein condensate (BEC). She did her Post-doctoral work at Laboratoire Kastler Brossel, Ecole Normale Superieure, Paris, in the Lab of Claude Cohen-Tannoudji (Nobel Laureate, Physics, 1997) where she worked on metastable He BEC experiment. She did her subsequent Post-doctoral research at the European Laboratory for Non-Linear Spectroscopy, Florence, Italy, where she worked on experiments on Efimov physics with ultra-cold atoms and 3D Anderson localisation of matter waves in disordered potentials.

She has won several awards and honours: the DST award for attending the Lindau Nobel laureates meeting, a Letter of appreciation from the Prime Minister of India for indigenously realising the first Bose-Einstein condensate in India and Outstanding Reviewer awards (2016 and 2019) from IOP Publishing, UK.

https://sites.google.com/view/sanjukta-roy/home



Myth :
Rydberg atoms are normal sized atoms.

Fact :
Rydberg atoms are giant-sized versions of regular atoms. Their "giant" aspect refers to their extended electron cloud.

An Interview with Prof. Arindam Ghosh

Professor Arindam Ghosh is a distinguished Indian experimental physicist specializing in condensed matter physics. He currently holds the position of Professor within the Department of Physics at the prestigious Indian Institute of Science in Bangalore, India. With a focus on Particles and Fields Physics, he has made significant contributions to the field of nanoscale electronics using semiconductors, and his work encompasses the study of physical phenomena at ultra-low temperatures.

Q: What sparked your interest in studying material properties, and what led you to focus specifically on Quantum materials?

I studied material properties because I have always been fascinated by quantum mechanics, and by the fact how quantum concepts determined the properties of materials from nano to macroscopic scales. The challenge in understanding quantum properties in complex quantum systems, such as high Tc superconductors or other systems with strong Coulomb interaction, also fascinated me because their properties cannot be easily computed, even with the best supercomputer in the world, but one needs innovative experimental strategies to uncover those mysteries.

Q: What potential applications or implications do you foresee for the next generation quantum materials in technological advancements or practical implementations?

Fundamentally, every material is quantum, and every technology and its advancements are built on material innovation. In the 1940s and 50s advancements in semiconductor material growth and devices gave us today's electronics and computers. Building on Li-ion cells in 1970s gave us the present-day battery technology. Material research, for example the perovskites, will bring better photovoltaic devices, two-dimensional materials may revolutionize electronics beyond 3 nm node, create the smart plastics, ceramics or light-weight composites, to building next gen products for quantum technologies (such as single photon detectors, defect- or spin-based sensors etc). There is enormous opportunity for material innovation to shape our technological future.

Q: Can you explain to our readers about the latest research happening in your lab on the multi-layer materials and their importance from an application perspective?

I work on certain classes of two-dimensional materials with which we make highly sensitive optoelectronic elements, ultra-thin thermoelectric devices or new types of neuromorphic memories that mimic the operation of neurons/synapses. We work on atomically thin layers of graphene, and its semiconducting analogues, such as transition metal dichalcogenides. We use these systems to create and manipulate optically excited quantum states, and use these states for quantum sensing purposes, such as single photon detection. My laboratory has built infrastructure for measuring noise in electrical signals from ultra-low to radio frequency range, which enables us to probe energy relaxation, dephasing in quantum devices etc.

Q: Looking towards the future, what are the key challenges and opportunities you foresee in the field of quantum sensing? Are there any particular research directions or technological advancements that you believe will shape the evolution of this field, particularly in the light of National Quantum Mission?

I believe quantum sensing will be among the first products of the 'quantum technologies' to reach the market. This is because quantum sensing will not only involve building large-scale complex systems, for example atom-based gravimetry or magnetic field sensing, but it will also create small standalone or even handheld defect-based sensors, such as the NV centers in diamond. The challenge is in creating an uninterrupted supply chain for such activities, and we will need to develop peripheral infrastructure so that all steps from R&D, product prototype demonstration to market-scale manufacturing can coexist. The National Quantum Mission needs to identify some of the 'low hanging fruits' in the sensing domain and create this infrastructure, while parallelly developing the large-scale integrated systems.

Q: How do you see quantum sensing evolving in the next decade? Can you identify any specific areas of research or technological advancements that you find particularly promising in terms of their potential impact or future developments?

As I mentioned in reply to the previous question, I expect quantum sensing to lead the productization of quantum technologies. The atomic clocks for time synchronization are already in the commercial domain. Central resources for metrology and standards could also become service provider for various public or strategic requirements. Standalone quantum optical sensors/elements, defect-based magnetometers for biological/health applications, or even peripheral quantum-inspired products, such as new forms of memories, spin-based products etc, will also come into the market sooner or later.

Q: Finally, as a distinguished researcher in the field of quantum materials and sensing, what message or key takeaway would you like to convey to the students and readers willing to pursue career in this field.

I see quantum technologies will be expanding in both the near- and long-term future. This is because there are already use cases that we are currently working on, and there will be many uses in the future that we are not even aware of today. This is probably most true for the quantum computing domain. We need to immediately start building adequate skilled human resource for quantum technology to grow and then sustain – not just programmers trained in python or qiskit, but also in hardware electronics and semiconductor technology, theoretical and experimental materials design/synthesis, RF/communication engineering etc. There will be jobs at various levels once quantum technology matures, not just in academic research but also in R&D units and industry. I believe there are bright career prospects for quantum-trained students and professionals.

QUANTUM EXPLORERS

MAPPING INDIA'S INNOVATORS IN SENSING AND METROLOGY

"Meet India's quantum pioneers in 'Quantum Explorers'. Discover how they're revolutionizing sensing and metrology, 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 Sensing & Metrology

Dr. Chandan Kumar

IISc, Bangalore

Dr. Chandan Kumar is an Assistant Professor at the Indian Institute of Science, Bangalore, where he leads the quantum 2D materials group. Previously a Postdoctoral Fellow at the Weizmann Institute of Science, Israel (2018-2022). He made significant contributions to groundbreaking research in the field.

Prof. Kasturi Saha

IIT Bombay

Prof. Kasturi Saha is associated with IIT Bombay. Her research interests include quantum sensing, nano-photonics, precision metrology, and quantum computation with solid-state color defects. She holds a Ph.D. from Cornell University and has earned recognition including the DST-INSPIRE faculty fellowship.

Dr. Ashok Mohapatra

NISER Bhubaneswar

Dr. Ashok Mohapatra holds the position of Associate Professor in Physical Sciences at the National Institute of Science Education and Research. His area of expertise lies within the realm of Physical Sciences, with a specific focus on Ultra-cold Atoms and Quantum Optics.

Dr. Goutam K Samanta

PRL, Ahmedabad

Guiding the Photonic Sciences Lab, Dr. Samanta specializes in quantum communication, advanced photon sources, quantum sensing, imaging, nonlinear optics, and structured beam applications, contributing to the forefront of photonics research.

Prof. Umakant D Rapol

IISER Pune

At IISER Pune, Prof. Rapol heads the Atomic Physics and Quantum Optics Lab, dedicated to precision spectroscopy and leveraging ultracold atoms and ions to uncover quantum mysteries and propel Quantum-enabled technologies.

Prof. Subhadeep De

IUCAA, Pune

With expertise spanning laser cooling, degenerate quantum gases, and quantum optics, Prof. Subhadeep De's experimental prowess drives advances in quantum metrology, quantum-enhanced technologies, precision measurements, and quantum dynamics using trapped atoms/ions.

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Quantum Sensing & Metrology

Dr. Sai Vinjanampathy

IIT Bombay

Dr. Sai Vinjanampathy is an Associate Professor at IIT Bombay, specializes in Quantum Information Theory, Quantum Control Theory, Quantum Synchronization, and Non-Equilibrium Statistical Mechanics.

Dr. Saikat Ghosh

IIT Kanpur

Dr. Saikat Ghosh is an Associate Professor at IIT Kanpur in the Department of Physics, specializing in Atomic and Molecular Physics, with expertise in Laser-Cooled Cold Atoms and Nano-photonics.

Prof. B K Sahoo

PRL, Ahmedabad

Prof. B K Sahoo is a distinguished Professor in the Atomic, Molecular, and Optical Physics Division, specializing in parity violation in atomic systems, quantum phase transitions in cold atoms, and high-precision atomic many-body theories. His contributions span testing the Standard Model, isotope shifts, and cosmological implications.

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.

Prof. Arindam Ghosh

IISc, Bangalore

Prof. Arindam Ghosh is leading the Quantum Materials and Devices Group at the IISc., focusing on two-dimensional hybrid material-based Optoelectronics and Spintronics. Research delves into quantum effects, carbon-based electronics, critical behavior in smart materials, and novel nano/micro-electromechanical sensing techniques.

Dr. Saptarishi Chaudhuri

RRI, Bangalore

Dr. Saptarishi Chaudhuri is an Associate Professor at RRI, Bangalore, specializing in laser cooling and trapping of neutral atoms. Research interests include spin correlation spectroscopy in neutral atoms and high-precision spectroscopy of cold Rydberg atoms.

QUANTUM EXPLORERS

Quantum Sensing & Metrology

Dr. Sanjukta Roy
RRI, Bangalore

Dr. Sanjukta Roy is a Principal Investigator at Raman Research Institute, specializes in Quantum Technologies using ultra-cold Rydberg atoms, Quantum Simulation with ultra-cold Quantum Mixtures in optical potentials, Spin correlation spectroscopy, and Few-body physics.

Dr. Ranjit Hawaldar
CMET, Pune

Dr. Ranjit Hawaldar is a Scientist at the Centre for Materials for Electronics Technology, specializing in Nanomaterials and Research and Development (R&D).
His research interests predominantly lie in Materials Chemistry and Nanotechnology.

Dr. Phani Kumar
IISER Bhopal

Dr. Phani Kumar is a Principal Investigator, with a research focus on Quantum sensing, specifically Nitrogen-Vacancy (NV) spins in diamond. He is actively engaged in the development of Hybrid quantum sensors, Nanoscale scanning diamond probes, and their applications in Magnetic resonance imaging and Biosensing.

Dr. Sapam Ranjita Chanu
IIT Kanpur

Dr. Sapam Ranjita Chanu is an Assistant Professor at IIT Kanpur, specializing in Experimental Atomic and Molecular Optical Physics and Quantum Optics. Dr. Sapam's research interests encompass Quantum computation and simulations using cold ions and atoms, as well as quantum metrology employing single pure states of cold atoms and ions.

Dr. Rajesh V. Nair
IIT Ropar

Dr. Rajesh is an Associate Professor in the Department of Physics at IIT Ropar, specializing in Quantum Nanophotonics/technologies, Quantum Materials and Devices, and Meta-materials.

Dr. Brajesh Kumar Mani
IIT Delhi

Dr. Brajesh Kumar Mani, is an Associate Professor at IIT Delhi, with a research focus on Computational Condensed Matter and Computational Atomic Physics.

QUANTUM EXPLORERS

Quantum Sensing & Metrology

Dr. Subhasis Panja
CSIR-NPL

Dr. Subhasis Panja is a Principal Scientist at CSIR-NPL, specializes in Ion Trap, Laser cooling, and Atomic Clocks. His research is multidisciplinary, covering Atomic & Molecular Physics, Laser Physics, and Timekeeping, with a particular focus on precise time and frequency transfer through optical fiber.

Dr. Vidya Praveen
IIT Madras

Dr. Vidya Praveen is an Assistant Professor at IIT Madras, with a research focus on Spin and photon-based Quantum technologies. His areas of interest include Experimental Condensed Matter, Magnetism and Magnetic Resonance, Scanned Probe Microscopy, Single photon emitters and detectors.

Dr. Kanhaiya Pandey
IIT Guwahati

Dr. Kanhaiya Pandey is an Associate Professor at IIT Guwahati, specializes in Atomic, molecular, and optical physics (Experiment). His research primarily revolves around Spectroscopy and frequency metrology of optical-atomic transitions.

Dr. Arijit Sharma
IIT Tirupati

Dr. Arijit Sharma, associated with IIT Tirupati, specializes in Experimental Atomic Physics and Quantum Optics. His research encompasses Fundamental Physics Searches and Metrology, Quantum communication and sensing.

Prof. Ambarish Ghosh
IISc, Bangalore

Prof. Ambarish Ghosh is an Associate Professor at IISc Bangalore. He is a leading researcher in the fields of magnetic nanoswimmers, quantum fluids, quantum sensing, driven colloids, plasmonics, and 2D materials, advancing cutting-edge science at the intersection of nanobiotechnology and quantum physics.

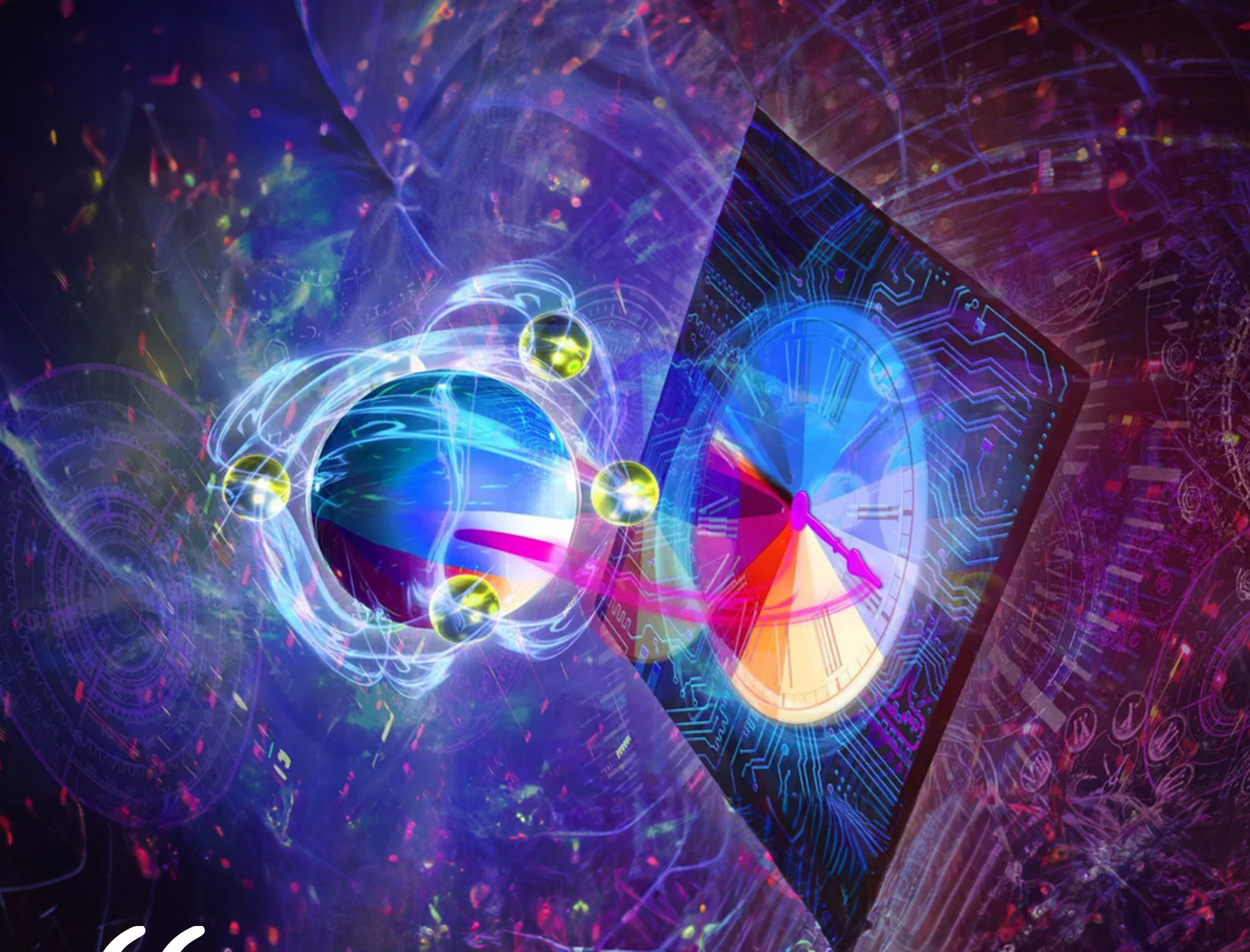
Prof. T. S. Mahesh
IISER Pune

Prof. Mahesh, a distinguished Professor at IISER Pune, is a renowned expert in Physics, specializing in Magnetic Resonance and Quantum Information Processing. His research contributions span NMR spectroscopy, optimal control, artificial intelligence, and quantum science.

*** 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 Currents

News and Updates from the Quantum Universe



“ India is getting ready for Quantum Computers ”

Shri Narendra Modi
Hon’ble Prime Minister of India highlighted in his speech during the 77th Independence Day.

NEWS

10 July 2023

India to launch quantum-secure communications satellite

The launch of the Quantum-Secure Communications Satellite by ISRO is a significant step towards the development of secure communication channels using quantum technologies.

The Indian Space Research Organisation (ISRO) plans to develop its Quantum Key Distribution (QKD) Satellite to enable secure and unhackable quantum communication capabilities. QKD, based on quantum physics principles, ensures secure data transport by sending traditional bits as data and decryption keys as quantum entangled states known as qubits.

ISRO's objective is to incorporate this technology into their satellites in order to achieve closed-loop communication with minimal signal weakening.

Source: DigWatch

14 - 15 July 2023

International Symposium on Quantum Computing and Innovations

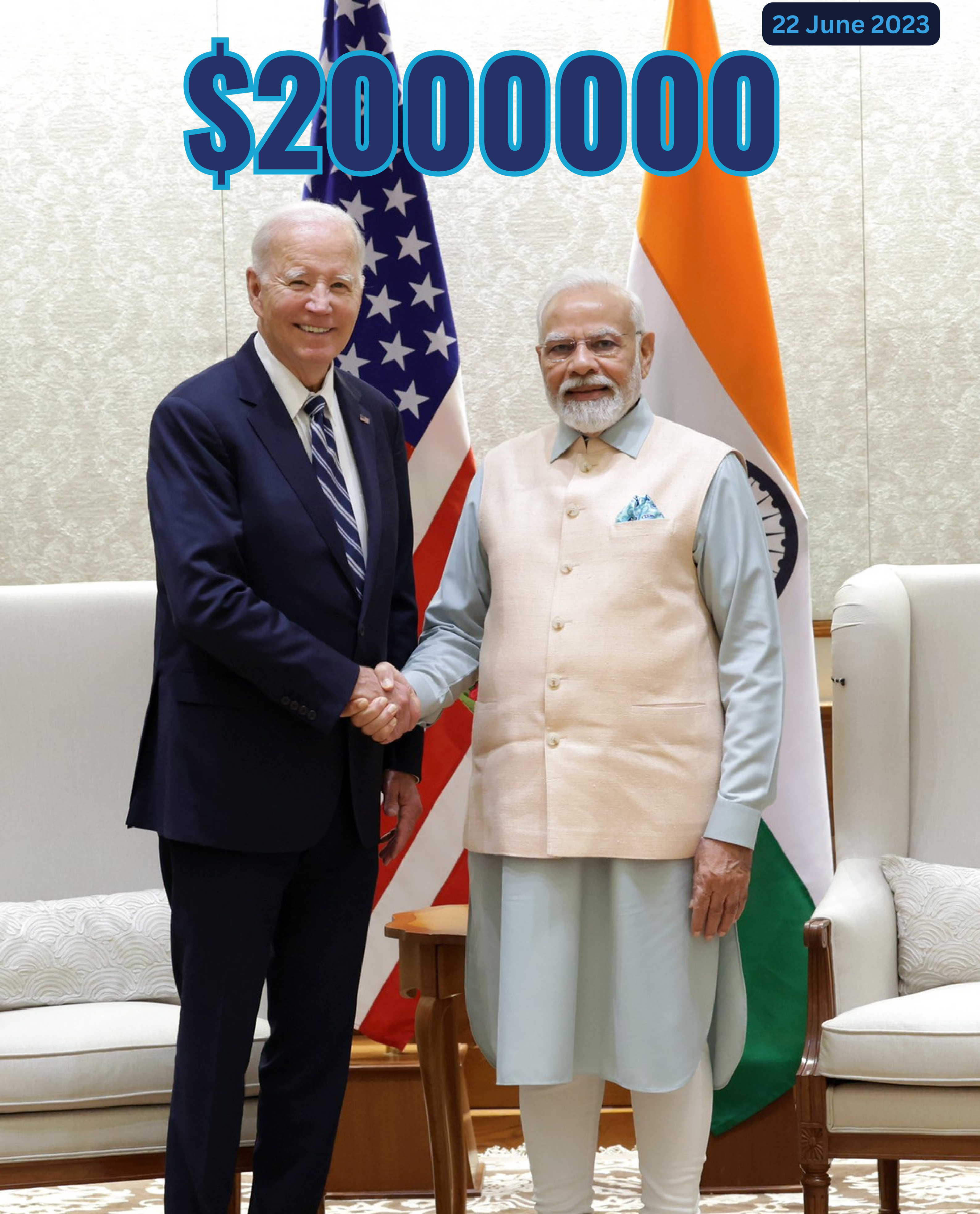
Aligned with the goals of the National Quantum Mission (NQM), C-DAC Patna & Kolkata organized an International Symposium on Quantum Computing and Innovations at IIT BHU Campus in Varanasi from July 14 to 15, 2023.

The Symposium aimed at the promotion, outreach, and discussion of thematic focus areas in the sphere of Quantum Computing. Eminent luminaries and domain experts assembled with the aspiration of sharing their experiences and knowledge, helping to realize the vision set in the National Quantum Mission.

The enthusiastic handholding of the patrons and participants succeeded in sculpting a strategic pathway towards the accomplishment of the global vision for a Quantum tomorrow.

22 June 2023

$2000000



$2 million grant program under the U.S.-India Science and Technology Endowment Fund

22 June 2023

Indo-U.S. Quantum Coordination Mechanism Established to Boost Collaboration in Quantum Technology and AI Development

President Biden and Prime Minister Modi have jointly established the Indo-U.S. Quantum Coordination Mechanism, aimed at facilitating collaboration among industry, academia, and government in the field of quantum technology. They expressed their commitment to working towards a comprehensive Quantum Information Science and Technology agreement. India's participation in the Quantum Entanglement Exchange and the Quantum Economic Development Consortium was welcomed by the United States, as it will foster expert and commercial exchanges with leading quantum nations.

Both countries are dedicated to sustaining and expanding quantum training and exchange programs, while also striving to reduce barriers to research collaboration between the United States and India.

The leaders also announced the launch of a $2 million grant program under the U.S.-India Science and Technology Endowment fund, which will support joint development and commercialization of Artificial Intelligence (AI) and quantum technologies. Encouraging public-private collaborations, they emphasized the need to develop high-performance computing (HPC) facilities in India.

President Biden reiterated his government's commitment to working with the U.S. Congress to lower barriers for exporting HPC technology and source code to India. Additionally, the U.S. side pledged to provide its support for India's Centre for Development of Advanced Computing (C-DAC) in joining the U.S. Accelerated Data Analytics and Computing (ADAC) Institute.

Source: Indian Express

June 27-30 2023

QUEST 2023: Shaping the Future of Quantum Technology

The dynamic city of Paris, renowned for its fusion of art, culture, and innovation, set the stage for a remarkable event—QUEST 2023: International Conference on Quantum Engineered Sensing and Information Technology.

Semiconductors: A Quantum Playground

At the forefront of this conference was the exploration of semiconductors—a realm where quantum engineering flourishes. These semiconductors, composed of diverse atoms from the periodic table, hold a treasure trove of optical and electronic properties. Precision electronic structure simulations now allow the intricate crafting of modern semiconductor quantum devices atom by atom, harnessing advanced growth techniques. This atomic mastery ingeniously blends elements into materials, imbuing them with unprecedented properties. The result? High-power, remarkably efficient quantum devices capable of converting electrical energy into coherent light and detecting light across a vast spectrum. The integration of these quantum wonders with silicon photonics further channels the potential of nature for the benefit of humanity.

Embracing the Quantum Future

QUEST 2023 exemplified the unwavering pursuit of knowledge and innovation within the quantum realm. As quantum technology strides forward, the potential knows no bounds. Conferences like QUEST 2023 stand as pillars, molding the contours of our quantum horizon.

July 10-21, 2023

Introduction to Precision Measurements and Quantum Metrology School

The world of quantum physics, a journey spanning a century, has transformed from theory to a powerful force. Quantum technologies are now revolutionizing various domains, with quantum systems enabling quantum computers, sensors, and encryption tools. The key lies in precision, pushing scientific boundaries.

Fostering Quantum Leaders

The recent "Precision Measurements and Quantum Metrology School" played a pivotal role in nurturing young quantum minds. These students are the future of India's National Quantum Mission.

The curriculum covered:

- Theory of Precision Measurements
- Theory of Estimation
- Classical and Quantum Metrology
- Atomic & Optical Physics Techniques
- Precision Measurements Using Quantum Systems

Expert speakers from India and other countries left an indelible mark on participants, inspiring them to dive deeper into the world of quantum physics and metrology.

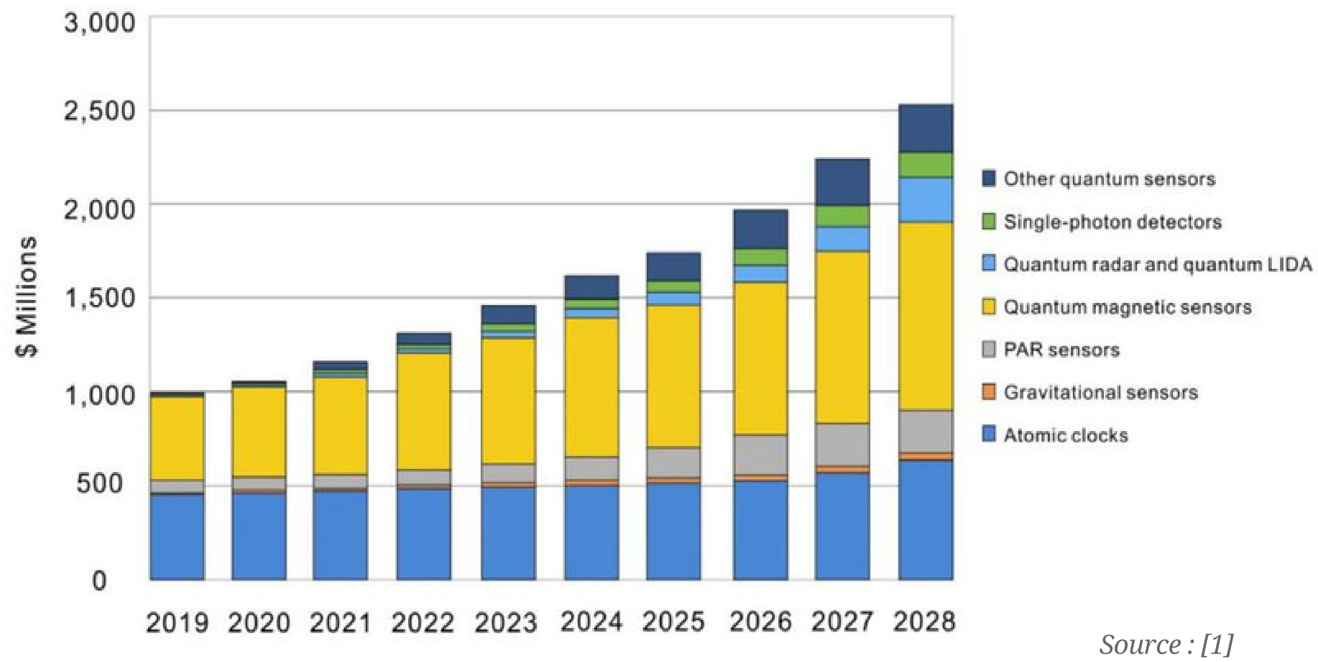
Diverse Participation

The school drew a diverse cohort:

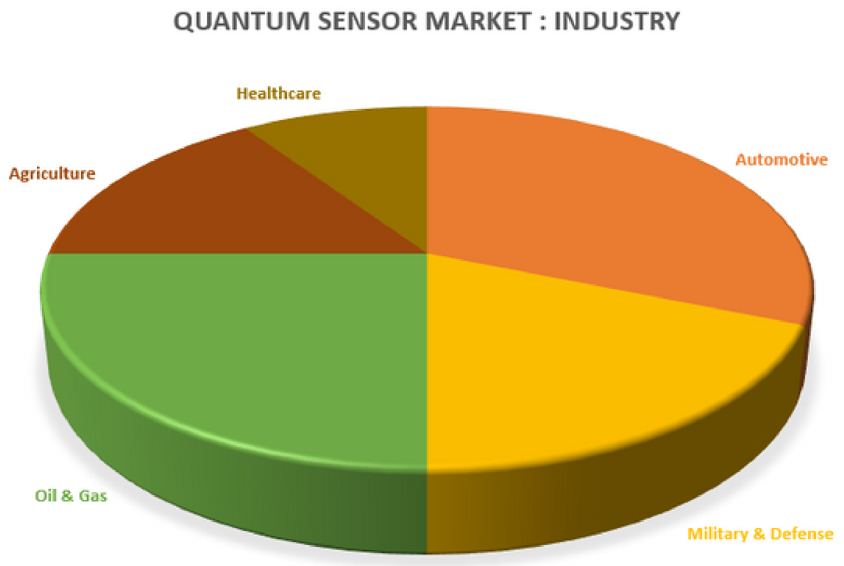
- M. Sc. 2nd-year students
- Ph.D. students
- Research fellows
- Post-doctoral researchers

This quantum journey continues, led by the passionate minds of tomorrow.

Ten-Year forecast of Quantum Sensor Markets



Source : [1]



Source : [2]

[1]: Quantum Sensors Markets, 2018 And Beyond - Report #IQT-QS-0119- Inside Quantum Technology Research- January 14, 2019
[2]: Aarti Dhapte - Quantum Sensors Market Research Report - MRFR/SEM/3835-CR - Market Research Future - February 2020

PUBLICATIONS

List of selected publications in Quantum Technologies during May to August 2023.

Entanglement-enhanced magnetic induction tomography *May 2023*	Physical Review Letters, 130 (20), 203602 *Zheng, W., Wang, H., Schmieg, R., Oesterle, A., & Polzik, E. S*
Polarization bases compensation towards advantages in satellite-based QKD without active feedback *May 2023*	Communications Physics, 6(1), 116 *Chatterjee, S., Goswami, K., Chatterjee, R., & Sinha, U*
Telecom-wavelength quantum repeater node based on a trapped-ion processor *May 2023*	Physical Review Letters, 130(21), 213601 *Krutyanskiy, V., Canteri, M., Meraner, M., Bate, J., Krcmarsky, V., Schupp, J., ... & Lanyon, B. P.*
Superconducting Microsphere Magnetically Levitated in an Anharmonic Potential with Integrated Magnetic Readout *May 2023*	Physical Review Applied, 19(5), 054047 *Latorre, M. G., Higgins, G., Paradkar, A., Bauch, T., & Wieczorek, W.*
Evidence for the utility of quantum computing before fault tolerance *June 2023*	Nature, 618(7965), 500-505 *Kim, Y., Eddins, A., Anand, S., Wei, K. X., Van Den Berg, E., Rosenblatt, S., ... & Kandala, A.*
Probing fundamental physics with spin-based quantum sensors *June 2023*	Physical Review A, 108(1), 010101 *Kimball, D. F. J., Budker, D., Chupp, T. E., Geraci, A. A., Kolkowitz, S., Singh, J. T., & Sushkov, A. O.*

FUN FACT

Quantum Party Crashers:

Quantum sensors are so sensitive that they can "crash" particles' private parties. They detect particles' properties even when those particles are trying to hide their secrets.

Experimental quantum communication overcomes the rate-loss limit without global phase tracking *June 2023*	Physical Review Letters, 130(25), 250801 *Zhou, L., Lin, J., Xie, Y. M., Lu, Y. S., Jing, Y., Yin, H. L., & Yuan, Z.*
Deep learning of quantum entanglement from incomplete measurements *July 2023*	Science Advances, 9(29), eadd7131 *Koutný, D., Ginés, L., Moczała-Dusanowska, M., Höfling, S., Schneider, C., Predojević, A., & Ježek, M.*
3D integration enables ultralow-noise isolator-free lasers in silicon photonics *August 2023*	Nature, 620(7972), 78-85 *Xiang, C., Jin, W., Terra, O., Dong, B., Wang, H., Wu, L., ... & Bowers, J. E.*

DID YOU KNOW?

Quantum Sensing Unveils the Unseen :
Quantum sensors can detect light particles (photons) beyond the visible spectrum, unlocking hidden details in materials and objects that our eyes can't perceive.

Quantum Sensors Spy on Submarines :
Quantum sensors play a crucial role in underwater surveillance, detecting faint magnetic fields and aiding in the detection of hidden submarines.

Quantum Sensors Make GPS Smarter :
Quantum-enhanced GPS systems are in development, promising ultra-precise navigation for everything from self-driving cars to interplanetary missions.

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