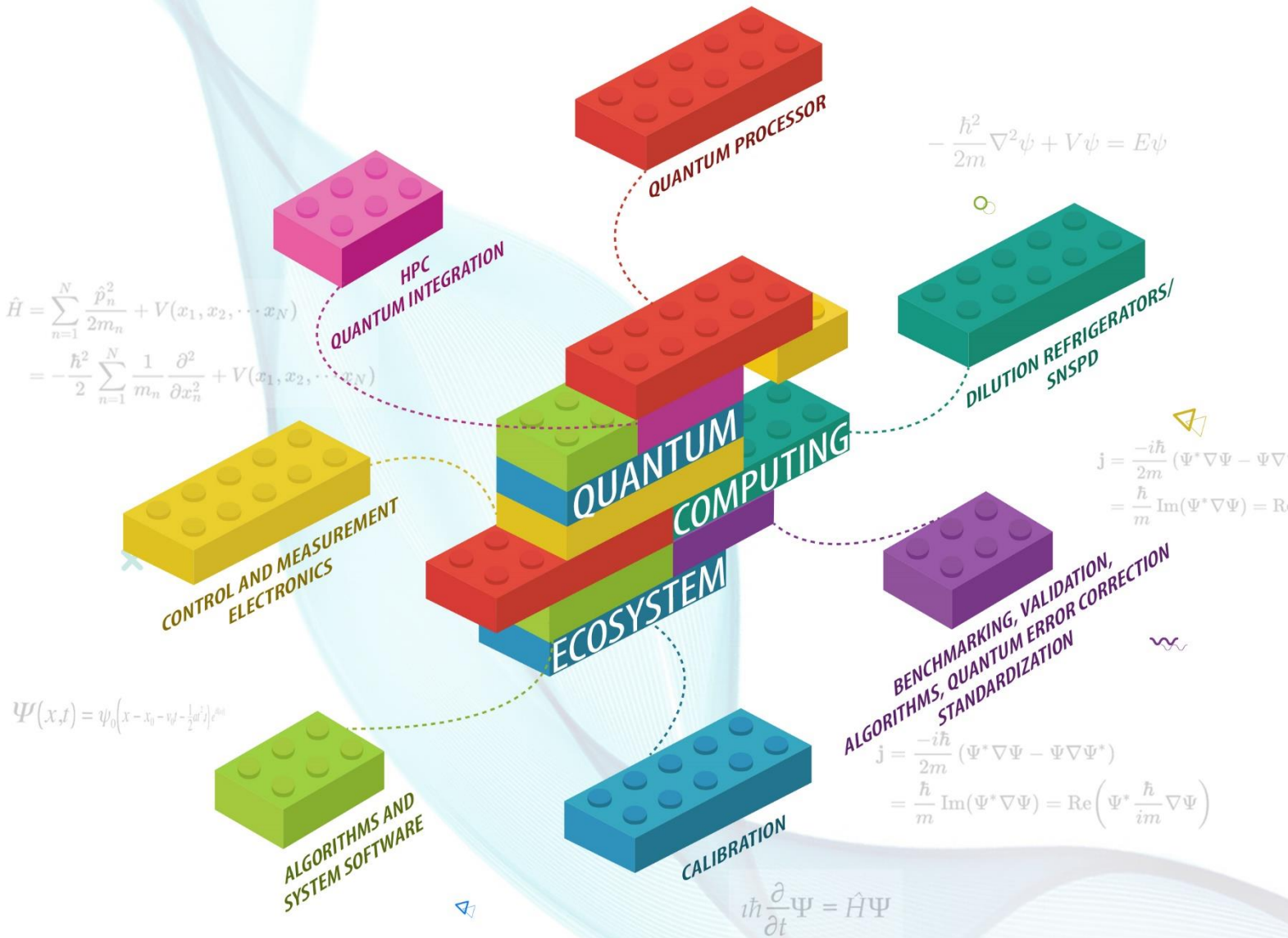


# SYMPOSIUM ON QUANTUM COMPUTING ECOSYSTEM: BASIC BUILDING BLOCKS



**Prof. Andrew Briggs**  
Professor of Nanomaterials,  
Department of Materials,  
University of Oxford  
& Chair QuantrolOx, UK



**Prof. Barry Sanders**  
Director,  
Institute for Quantum  
Science and Technology,  
University of Calgary, Canada



**Dr. Jan Goetz**  
CEO & Co-Founder,  
IQM Quantum Computers,  
Finland



**Ms. Aparna Prabhakar,**  
Vice President,  
IBM Quantum Partners & Alliances



**Dr. R. Vijayaraghavan**  
Associate Professor,  
Quantum Measurement and  
Control Laboratory (QuMaC),  
DCMPMS, Tata Institute of  
Fundamental Research, Mumbai



**Miss. Laura Schulz**  
Acting Dept. Head,  
Quantum Computing and Technologies  
Leibniz Supercomputing Centre (LRZ),  
Germany

Let's listen to the experts pry open a Quantum Computer and get it back to work. Let us all Quantum Computing enthusiasts, entrepreneurs, subsystem manufacturers / aspirants get together and sculpt the contours of Quantum Computing in India.

$$-\frac{\hbar^2}{2m}\nabla^2\psi + V\psi = E\psi$$

# Symposium on Quantum Computing Ecosystem (Q-Symp): Basic Building Blocks

**Dates: 30<sup>th</sup>-31<sup>st</sup> Jan 2023**

## Preamble:

C-DAC has been developing indigenous supercomputing systems and interconnect products since its inception in 1988 and possesses extensive in-house expertise required for development and technology transfer of various state-of-the-art hardware and software components. With the recent meteoric progress in quantum computing technology, the quantum processor with its unique properties has established itself as a computational accelerator promising exceptional performance beyond the scope of conventional classical computers in near future. C-DAC has already identified quantum computing as one of its mission areas. C-DAC has co-developed a Quantum Computing simulator QSim along with IISc Bangalore and IIT Roorkee, capable of simulating the quantum gate model.

## Q-Symp:

C-DAC is organizing a symposium to explore the technologies, systems and subsystems (including software stack, error correction etc.) that make quantum computers' building blocks. The symposium aims to bring together all the players both Indian and global in the quantum computing ecosystem together on a single platform and look at various factors which would lead to sustainability and accelerate engineering advancements in the associated state-of-the-art technologies.

## Focus areas:

The symposium will take place over two days and will feature a variety of talks, panel discussions, and breakout sessions on the following focus areas:

- Superconducting and Photonic based Quantum Processor
- Control and Measurement electronics, Calibration
- Dilution refrigerators and SNSPD
- Other Quantum Processor Technologies
- Software Stack and Simulators
- Integrated HPC and Quantum Computing Platform and use cases, Benchmarking, Validation and Cloud
- Quantum Algorithms and Quantum Error Correction
- Emerging Indian Quantum Computing Roadmap

$$\hat{H} = \sum_{n=1}^N \frac{\hat{p}_n^2}{2m_n} + V(x_1, x_2, \dots, x_N)$$

$$= -\frac{\hbar^2}{2} \sum_{n=1}^N \frac{1}{m_n} \frac{\partial^2}{\partial x_n^2} + V(x_1, x_2, \dots, x_N)$$

$$j = \frac{-i\hbar}{2m} (\Psi^* \nabla \Psi - \Psi \nabla \Psi^*)$$

$$= \frac{\hbar}{m} \text{Im}(\Psi^* \nabla \Psi) = \text{Re} \left( \Psi^* \frac{\hbar}{im} \nabla \Psi \right)$$

$$i\hbar \frac{\partial}{\partial t} \Psi = \hat{H} \Psi$$

$$j = \frac{-i\hbar}{2m} (\Psi^* \nabla \Psi - \Psi \nabla \Psi^*)$$

$$= \frac{\hbar}{m} \text{Im}(\Psi^* \nabla \Psi) = \text{Re} \left( \Psi^* \frac{\hbar}{im} \nabla \Psi \right)$$

# Speakers and Panelists

$$-\frac{\hbar^2}{2m}\nabla^2\psi + V\psi = E\psi$$

## CATEGORY 1: Key Note speakers

- Prof. Barry Sanders, University of Calgary, Canada
- Prof. Andrew Briggs, Oxford University and Chair QuantrolOx, UK
- Dr. R. Vijayaraghavan, Tata Institute of Fundamental Research, Mumbai
- Ms. Aparna Prabhakar, Vice President, IBM Quantum Partners & Alliances
- Dr. Jan Goetz, CEO & Co-founder, IQM Quantum Computers, Finland
- Ms. Laura Schulz, Acting Department Head, Quantum Computing and Technologies Leibniz Supercomputing Centre (LRZ), Germany

## CATEGORY 2: Expert speakers

- Mr. Matthijs Rijlaarsdam, QuantWare, Netherlands
- Prof. Gregory N. Goltsman, Moscow State Pedagogical University (Scontel)
- Mr. Bryan Choo, Founder, Maybell Quantum Industries
- Dr. Itamar Sivan, CEO, Quantum Machines, Israel
- Dr. Niels Bultink, Co-founder & CEO, QBlox, Netherlands
- Dr. Sadik Hafizovic, CEO & Co-founder, Zurich Instruments, Zurich, Switzerland
- Mr. Nitin Nigam, Solution Engineer, Keysight Technologies
- Dr. Himadri Majumdar, CEO, SemiQon, Finland
- Dr. Abhishek Shukla, University of Hasselt, Belgium
- Dr. Mikael Johansson, Quantum Strategist, CSC-IT Centre for Science, Finland
- Dr. David Gunnarsson, CTO, Blufors, Helsinki, Finland

## CATEGORY 3: Panel speakers

- Dr. Baladitya Suri, IISc Bangalore
- Dr. C. M. Chandrashekar, IISc Bangalore
- Prof. Gopalan Raghavan, Director, SQT, DIAT Pune
- Dr. Joyee Ghosh, IIT Delhi
- Prof. B. K. Das, IIT Madras
- Dr. Anuj Bhatnagar, SAMEER, Mumbai
- Dr. Ranjit Hawaldar, C-MET Pune
- Mr. Sujoy Chakravarty, Co-founder and Board Member, Quanfluence Pvt. Ltd.
- Dr. Manjunath RV, SD, Quantum Hardware (QpiAI), Qpi Technology
- Prof. Arvind, Dean R&D, IISER Mohali, and Vice Chancellor Punjabi University
- Mr. Mark Elo, CMO & GM, Tabor Electronics Ltd.
- Mr. Krishnakumar Rao S., C-DAC Trivandrum
- Dr. Anirban Mukherjee, TCS, Mumbai
- Dr. Vishvendra Singh Poonia, IIT Roorkee
- Dr. Goutam Paul, ISI Kolkata
- Prof. Umakant Rapol, IISER, Pune
- Prof. Shubhadeep De, IUCAA, Pune
- Prof. Kavita Dorai, IISER, Mohali
- Dr. Saptarishi Chaudhuri, RRI Bangalore
- Dr. Kasturi Saha, IIT Bombay
- Dr. Amit Saha, Scientist, ATOS

$$j = \frac{-i\hbar}{2m} (\Psi^* \nabla \Psi - \Psi \nabla \Psi^*)$$
$$= \frac{\hbar}{m} \text{Im}(\Psi^* \nabla \Psi) = \text{Re} \left( \Psi^* \frac{\hbar}{im} \nabla \Psi \right)$$

$$i\hbar \frac{\partial}{\partial t} \Psi = \hat{H} \Psi$$

$$j = \frac{-i\hbar}{2m} (\Psi^* \nabla \Psi - \Psi \nabla \Psi^*)$$
$$= \frac{\hbar}{m} \text{Im}(\Psi^* \nabla \Psi) = \text{Re} \left( \Psi^* \frac{\hbar}{im} \nabla \Psi \right)$$

- Dr. Manish Modani, Principal Solution Architect, NVIDIA
- Mr. Asvija B., C-DAC Bangalore
- Mr. Vivek Nainwal, C-DAC Hyderabad
- Mrs. R. Rajaminakshi, C-DAC Pune
- Dr. Gurmohan Singh, C-DAC Mohali
- Mr. Samrit Maity and Mr. Amit Saxena, C-DAC Pune
- Dr. Santu Sardar, Director, DYSL-QT
- Dr. Mamta Khaneja, Scientist-F, SSPL, DRDO
- Prof. Kailash C. Rustagi, Ex-Head, RRCAT Indore
- Mr. Pradeep Kumar, Director, Qbit Labs Pvt. Ltd.
- Dr. Jedidiah Pradhan, Dr. Vikas Singhal, Variable Energy Cyclotron Centre (VECC), Kolkata
- Mr. Aasheesh Chudasama, Business Finland
- Mr. Sunil Gupta, Co-Founder, and CEO, QNu Labs Pvt. Ltd.
- Prof. Prabhakar Krishnan, Amrita University
- Dr. Harish Sahu, SAG, DRDO
- Mr. Manikandan K., Bureau of Indian Standards
- Dr. V. R. Chelle, Director, Quantum Technology, DoT
- Prof. Anil Prabhakar, IIT Madras
- Prof. Monika Aggarwal, Co-founder, Qkrishi Quantum Pvt. Ltd.
- Prof. Apoorva Patel, IISc Bangalore
- Prof. Prasanta K. Panigrahi, IISER Kolkata
- Prof. Amlan Chakrabarti, University of Calcutta, Kolkata
- Prof. Anirban Pathak, HOD, IIIT, Noida
- Prof. Bhanu Pratap Das, TCG Crest, Kolkata
- Dr. Natarajan Venkatachalam, SETS, Chennai
- Dr. L. Venkata Subramaniam, IBM
- Dr. Sangeeta Maini, CEO, I-HUB QTF, Pune
- Dr. Nikhil Malhotra, Tech Mahindra, Pune

$$\Psi(x,t) = \psi(x) e^{-i(Et - \hbar kx)}$$

### Stalls by Quantum Technology Industry:

- Quantum Machines, Israel
- Qblox Quantum, Netherlands
- Keysight Technologies
- Tektronix India Pvt. Ltd.
- Atos Instruments
- Zurich Instruments Ltd., Switzerland

$$j = \frac{-i\hbar}{2m} (\Psi^* \nabla \Psi - \Psi \nabla \Psi^*)$$

$$= \frac{\hbar}{m} \text{Im}(\Psi^* \nabla \Psi) = \text{Re} \left( \Psi^* \frac{\hbar}{im} \nabla \Psi \right)$$

$$i\hbar \frac{\partial}{\partial t} \Psi = \hat{H} \Psi$$

$$\hat{H} = \sum_{n=1}^N \frac{\hat{p}_n^2}{2m_n} + V(x_1, x_2, \dots, x_N)$$

$$= -\frac{\hbar^2}{2} \sum_{n=1}^N \frac{1}{m_n} \frac{\partial^2}{\partial x_n^2} + V(x_1, x_2, \dots, x_N)$$

$$j = \frac{-i\hbar}{2m} (\Psi^* \nabla \Psi - \Psi \nabla \Psi^*)$$

$$= \frac{\hbar}{m} \text{Im}(\Psi^* \nabla \Psi) = \text{Re} \left( \Psi^* \frac{\hbar}{im} \nabla \Psi \right)$$

## Technical Programme:

(will be updated periodically)

$$-\frac{\hbar^2}{2m}\nabla^2\psi + V\psi = E\psi$$

## Webcast links:

<https://www.facebook.com/CDACINDIA/>

<https://www.youtube.com/@CDACOfficial/streams>

## Venue:

Centre for Development of Advanced Computing (C-DAC), Innovation Park,  
Panchavati, Pashan, Pune - 411 008, India.

## Convenor

Dr. Anindita Banerjee, Adjunct Scientist

## Contact:

Mr. Deepu CV, OSD to ED 9881132551 Mail to [sqc@cdac.in](mailto:sqc@cdac.in)

$$\Psi(x,t) = \psi_0(x-x_0 - \frac{1}{2}at^2)e^{i\phi}$$

$$i\hbar\frac{\partial}{\partial t}\Psi = \hat{H}\Psi$$

$$\begin{aligned}\hat{H} &= \sum_{n=1}^N \frac{\hat{p}_n^2}{2m_n} + V(x_1, x_2, \dots, x_N) \\ &= -\frac{\hbar^2}{2} \sum_{n=1}^N \frac{1}{m_n} \frac{\partial^2}{\partial x_n^2} + V(x_1, x_2, \dots, x_N)\end{aligned}$$

$$\begin{aligned}j &= \frac{-i\hbar}{2m} (\Psi^* \nabla \Psi - \Psi \nabla \Psi^*) \\ &= \frac{\hbar}{m} \text{Im}(\Psi^* \nabla \Psi) = \text{Re} \left( \Psi^* \frac{\hbar}{im} \nabla \Psi \right)\end{aligned}$$

$$\begin{aligned}j &= \frac{-i\hbar}{2m} (\Psi^* \nabla \Psi - \Psi \nabla \Psi^*) \\ &= \frac{\hbar}{m} \text{Im}(\Psi^* \nabla \Psi) = \text{Re} \left( \Psi^* \frac{\hbar}{im} \nabla \Psi \right)\end{aligned}$$

# Symposium on Quantum Computing (30<sup>th</sup> - 31<sup>st</sup> January 2023)

## Program Schedule

### **DAY 1 – 30<sup>th</sup> January 2023**

09.00 – 09.40	Keynote Talk	Prof. Barry Sanders, University of Calgary, Canada
09.40 – 09.45		Welcome address by <b>Col. A.K. Nath (Retd.)</b> , Executive Director, Corporate Strategy and C-DAC, Pune
09.45 – 09.50		Address by <b>Dr. Ekta Kapoor</b> , Head, FFT Division, DST ( <b>Online address</b> )
09.50 – 09.55		Address by <b>Smt. Sunita Verma</b> , Group Coordinator, R&D in IT, MeitY
09.40 – 11.00	09.55 – 10.00	Address by <b>Dr. Preeti Banzal</b> , Scientist 'G'/Adviser, O/o Principal Scientific Adviser
<b>Inaugural session</b>	10.00 – 10.10	Address by <b>Shri E. Magesh</b> , DG, C-DAC
	10.10 – 10.20	Address by <b>Shri Bhuvnesh Kumar</b> , Additional Secretary, MeitY
	10.20 – 10.40	Address by <b>Shri Alkesh Kumar Sharma</b> , Secretary, MeitY ( <b>Online address</b> )
	10.40 – 11.00	Address by Chief Guest- <b>Shri Rajeev Chandrasekhar</b> , Hon'ble Minister of State in the Ministry of Skill Development and Entrepreneurship; and Electronics and Information Technology. ( <b>Online address</b> )
11.00 – 11.40	Keynote talk	Prof. Andrew Briggs, Oxford University & Chair QuantrolOx, UK

#### **11.40 – 11.50: Tea break**

#### **Session I: Superconducting and Photonic-based Quantum Processor**

Chair: Mr. Hari Babu Pasupuleti, AD, C-DAC Bangalore

Coordinator-1: Mr. Abhishek Tiwari, JD, C-DAC Noida

Coordinator-2: Mr. Vivek Nainwal, JD, C-DAC Hyderabad

11.50 – 12.30	Keynote Talk	Dr. R. Vijayaraghavan, TIFR, Mumbai
12.30 – 12.50	Expert Speaker	Mr. Matthijs Rijlaarsdam, QuantWare, Netherlands
12.50 – 14.00	Panel Discussion	Dr. Baladitya Suri, IISc Bangalore
		Dr. C. M. Chandrashekar, IISc Bangalore
		Prof. Gopalan Raghavan, Director, SQT, DIAT Pune
		Prof. B. K. Das, IIT Madras
		Dr. Anuj Bhatnagar, SAMEER, Mumbai
		Dr. Ranjit Hawaldar, C-MET Pune
		Mr. Sujoy Chakravarty, Quanfluence
		Dr. Joyee Ghosh, IIT Delhi

#### **14.00 – 15.00: Lunch**

## Session II: Dilution refrigerators and SNSPD

Chair: Mr. S. A. Kumar, Advisor, C-DAC

Coordinator-1: Mr. Amit Saxena, JD, C-DAC Pune

Coordinator-2: Mr. Amit Srivastava, JD, C-DAC Pune

15.00 – 15.20	Expert talk	Prof. Gregory N. Goltsman, Moscow State Pedagogical University (Scontel)
15.20 – 15.40	Expert talk	Mr. Bryan Choo, Founder, Maybell Quantum Industries, USA
15.40 – 15.50	Talk	Dr. Jedidiah Pradhan, Scientist G, Variable Energy Cyclotron Centre (VECC), Kolkata

## Session III: Control and Measurement Electronics and Calibration

Chair: Dr. S. D. Sudarshan, ED, C-DAC Bangalore

Coordinator-1: Mr. Umang Dubey, KA, C-DAC Pune

Coordinator-2: Mr. Gyan Pratipat, TO, C-DAC Patna

15.50 – 16.10	Expert Talk	Dr. Itamar Sivan, Quantum Machines, Tel Aviv-Yafo, Israel
16.10 – 16.30	Expert Talk	Prof. Andrew Briggs, Oxford University & Chair QuantrolOx, UK
16.30 – 16.50	Expert Talk	Dr. Niels Bultink, Cofounder & CEO QBlox, Randstad, Netherlands

### 16.50 – 17.00: Tea break

17.00 – 17.20	Expert Talk	Dr. Sadik Hafizovic, CEO & Co-founder, Zurich Instruments Ltd., Switzerland
17.20 – 17.40	Expert Talk	Mr. Nitin Nigam, Solution Engineer, Keysight Technologies
17.40 – 18.10	Panel Discussion	Dr. Manjunath R. V., Senior Director of Quantum Hardware, QpiAI Mr. Mark Elo, CMO & GM, Tabor Electronics Ltd. Mr. Krishnakumar Rao S., C-DAC Trivandrum

## Session IV: Quantum Algorithms and Quantum Error Correction

Chair: Mr. Aditya Kumar Sinha, Director, C-DAC Patna

Coordinator-1: Mr. Soumya Bhowmik, PTO, C-DAC Patna

Coordinator-2: Mr. Shashank Sharma, PTO, C-DAC Pune

18.10 – 18.50	Panel Discussion	Dr. Vishvendra Singh Poonia, IIT Roorkee Dr. Anirban Mukherjee, TCS, Mumbai Dr. L. Venkata Subramaniam, IBM Dr. Nikhil Malhotra, Tech Mahindra, Pune
---------------	------------------	---

### Conference Dinner at Rooftop Cafeteria

## DAY 2 – 31<sup>st</sup> January 2023

09.00 – 09.20 Keynote Talk Ms. Aparna Prabhakar, Vice President, IBM Quantum Partners & Alliances

### Session V: Other Quantum Processor Technologies

Chair: Mrs. Lakshmi Eswari P. R., Centre Head, C-DAC Hyderabad

Coordinator-1: Mr. Anoop Kumar, Associate Director, C-DAC Hyderabad

Coordinator-2: Dr. Kunal Abhishek, JD, C-DAC Patna

09.20 – 10.10 Panel Discussion Prof. Umakant Rapol, IISER, Pune  
Prof. Shubhadeep De, IUCAA, Pune  
Prof. Kavita Dorai, IISER, Mohali  
Dr. Saptarishi Chaudhuri, RRI Bangalore  
Dr. Kasturi Saha, IIT Bombay

### 10.10 – 10.20: Break

### Session VI: Software Stack and Simulators

Chair: Mr. Jitesh Choudhary, Director, C-DAC Silchar

Coordinator-1: Mr. Henry Kumar S., JD, C-DAC Bangalore

Coordinator-2: Mr. Shashank Sharma, PTO, C-DAC Pune

10.20 – 11.00 Panel Discussion Dr. Amit Saha, Scientist, ATOS  
Dr. Manish Modani, Principal Solution Architect, NVIDIA  
Mr. Asvija B., C-DAC Bangalore  
Mr. Vivek Nainwal, C-DAC Hyderabad

11.00 – 11.20 Expert Talk Dr. Himadri Majumdar, CEO, SemiQon, Helsinki, Finland

11.20 – 11.40 Expert Talk Dr. Abhishek Shukla, University of Hasselt, Belgium

11.40 – 12.20 Keynote Talk Dr. Jan Goetz, CEO & Co-founder IQM Quantum Computers, Finland

### Session VII: Integrated HPC and Quantum Computing Platform, Use cases, Benchmarking, Validation and Cloud

Chair: Mr. Sanjay Wandhekar, Senior Director & HOD, HPC Tech, C-DAC Pune

Coordinator-1: Mr. Samrit Kumar Maity, JD, C-DAC Pune

Coordinator-2: Ms. Jyoti Faujdar, KA, C-DAC Mumbai

12.20 – 13.00 Keynote Talk Ms. Laura Schulz, Acting Department Head, Quantum Computing and Technologies Leibniz Supercomputing Centre (LRZ), Germany

13.00 – 13.20 Expert Talk Dr. Mikael Johansson, Quantum Strategist, CSC - IT Center for Science, Finland

13.20 – 14.00 Panel Discussion Mrs. R. Rajaminakshi, C-DAC Pune  
Dr. Gurmohan Singh, C-DAC Mohali  
Mr. Samrit Maity and Mr. Amit Saxena, C-DAC Pune



### Session VIII: Valedictory session (Emerging Indian Quantum Computing Roadmap)

Chair: Col. A. K. Nath (Retd.), Executive Director, Corporate Strategy and C-DAC Pune

Coordinator: Dr. Anindita Bannerjee, Adjunct Scientist, Corporate R&D and C-DAC Pune

15.00 – 16.00 Valedictory Session

Prof. Kailash C. Rustagi, Ex-Head, RRCAT Indore  
Prof. Arvind, Dean R&D, IISER Mohali and Vice Chancellor Punjabi University  
Dr. Mamta Khaneja, Scientist-F, SSPL, DRDO  
Dr. Santu Sardar, Director, DYSL-QT  
Dr. Sangeeta Maini, CEO, I-HUB QTF, Pune  
Dr. Harish Sahu, SAG, DRDO  
Dr. V. R. Chelle, Director, Quantum Technology, DoT  
Prof. Anil Prabhakar, IIT Madras  
Mr. Manikandan K., Bureau of Indian Standards  
Mr. Aasheesh Chudasama, Business Finland  
Dr. Goutam Paul, ISI, Kolkata  
Dr. Prabhakar Krishnan, Amrita University  
Mr. Sujoy Chakravarty, Quanfluence  
Prof. Monika Aggarwal, Co-founder, Qkrishi Quantum Pvt. Ltd.  
Dr. Jedidiah Pradhan, Dr. Vikas Singhal, Variable Energy Cyclotron Centre (VECC), Kolkata  
Mr. Pradeep Kumar, Director, Qbit Labs Pvt. Ltd.  
Mr. Sunil Gupta, Co-Founder and CEO, QNu Labs Pvt. Ltd.

### Session IV (continued): Quantum Algorithms and Quantum Error Correction

Chair: Dr. Rajendra Joshi, Senior Director & HOD, HPC-M & BA Group, C-DAC Pune

Coordinator-1: Dr. Gurmohan Singh, JD, C-DAC Mohali

Coordinator-2: Mr. Tapas Saini, JD, C-DAC Hyderabad

16.00 – 17.20 Panel Discussion

Prof. Apoorva Patel, IISc Bangalore  
Prof. Prasanta K. Panigrahi, IISER Kolkata  
Prof. Amlan Chakrabarti, University of Calcutta, Kolkata  
Prof. Anirban Pathak, HOD, IIIT, Noida  
Prof. Bhanu Pratap Das, TCG Crest, Kolkata  
Dr. Natarajan Venkatachalam, SETS, Chennai  
Dr. Goutam Paul, ISI Kolkata

### 17.20 – 17.45: Tea break

17.45 – 18.05 Expert Talk

Dr. David Gunnarsson, CTO, Blufors, Helsinki, Finland

### Session IX: Standardization

Chair: Col. A. K. Nath (Retd.), Executive Director, Corporate Strategy and C-DAC Pune

Coordinator 1: Dr. Anindita Bannerjee, Adjunct Scientist, Corporate R&D and C-DAC Pune

Coordinator 2: Mr. Prathamesh Bhole, KA, C-DAC Pune

18.05 – 18.35 Panel speaker

Mr. Manikandan K., Bureau of Indian Standards  
Panel speaker

Dr. Harish Sahu, SAG, DRDO  
Panel speaker

Dr. V. R. Chelle, Director, Quantum Technology, DoT