LAKIREDDY BALI REDDY COLLEGE OF ENGINEERING
(AUTONOMOUS)
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Approved by AICTE, New Delhi and Affiliated to JNTUK, Kakinada
L.B.Reddy Nagar, Mylavaram-521230, NTR Dist, Andhra Pradesh, India

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Report on One Week Online FDP on "Quantum Signal Processing " using Microsoft Teams

Event Type : FACULTY DEVELOPMENT PROGRAM (FDP)

Date / Duration : 14th – 20th December, 2023 (ONE WEEK)

Resource Persons :

1. **Dr. Ashok Vudayagiri, Associate Professor, University of Hyderabad**
2. **Dr. Prasantha K panigrahi, Professor, IISER, Kolkata**
3. **Dr.G.L.N. Murthy, Professor, Lakireddy Bali Reddy College of Engineering, Mylavaram**
4. **Dr. Alok Kumar Pan, Associate Professor, IIT, Hyderabad**
5. **Dr. Amit kumar Datta, Assistant Professor ,IIT, Kharagpur**

Convener : Dr. Y. Amar Babu, professor & HoD

Coordinators : Dr. G L N Murthy, Professor
Co-Coordinators : Mr. M.K.Linga Murthy, Sr. Assistant Professor
Mr.M.Sambasiva Reddy, Sr. Assistant Professor

Target Audience : 250

Total no of Participants: 208 (Internal Count=15 & External Count=193)

Objective of the event: The objective of this FDP is to introduce Quantum Signal Fundamentals. Further it is also aimed at introducing the knowledge about quantum entanglement and its applications will be given along with representation of Quantum gates and their properties. Knowledge about Quantum representation of classical Signals will also be introduced.

Outcome of event :

1) Understand the Quantum Phenomena including super position, entanglement and Quantum measurement.
2) Acquire the knowledge on Applications of Quantum Signal Processing.
3) Learn basic programming fundamentals in the Qiskit Environment.

Description / Report on Event:

The one week online FDP program began with Inaugural function that was addressed by Principal Dr.K.Appa Rao , Head of the Department Dr.Y.Amar Babu. In his inaugural speech, Dr.Y.Amar Babu highlighted the significance of Quantum Mechanics. It was mentioned that that Physics plays a prominent role in coping up with the developments in Quantum Computing. In his inaugural address, Dr.K. Appa Rao highlighted the importance of Quantum signal Processing. It was told that Government is spending large amount of money in promoting the research in the Quantum domain. Being a multi-disciplinary area, it should be learnt by all those involved in research irrespective of specialization, as mentioned by Dr.K.Appa Rao. All the participants are advised to actively participate in all the sessions and gain practical knowledge.

The day 1 session by Dr.Ashok began with the introduction of Classical mechanics that is a branch of physics that deals with the motion of objects, incorporating Newton's laws of motion and the law of universal gravitation. This was followed by an overview of simple harmonic oscillator that is a type of mechanical or physical system that exhibits a particular type of repetitive, back-and-forth motion called simple harmonic motion (SHM). The motion is characterized by a restoring force that is directly proportional to the displacement from the equilibrium position and is directed opposite to that displacement. This type of motion is common in various physical systems and can be described by a sinusoidal function. Schrödinger's equation is a fundamental equation in quantum mechanics that describes how the quantum state of a physical system changes over time was also elaborated. The equation is central to understanding the behaviour of quantum systems, including electrons in atoms and molecules.

In quantum mechanics, vector space plays a fundamental role in describing the state of quantum system. Quantum states are represented by vectors in a complex vector space. This mathematical framework provides a concise and powerful way to describe the various properties and behaviours of quantum systems. The key aspects of vector spaces in the context of quantum mechanics like Hilbert Space, Quantum States as Vectors and numerous Operators were also explained. The mathematical framework of vector spaces and Hilbert spaces provides a rigorous foundation for the formulation of quantum mechanics and allows for the precise description of quantum states, evolution, and measurements.

On Day 2, Dr.Prasantha K Panigrahi from iISER, Kolkata explored the development Quantum Computing Domain. It was mentioned that till now the Quantum Computing facility is available with IBM primarily while other Technological giants like Google have started to work in the emerging domain. The concept of traversable wormholes is primarily rooted in theoretical physics, particularly in the context of general relativity was introduced. Traversable wormholes are hypothetical structures that could connect two separate points in spacetime, potentially allowing for faster-than-light travel or shortcuts between distant regions of the universe. It was told that for the first time in the country,

Indian Space Research Organisation (ISRO) has successfully demonstrated free-space Quantum Communication over a distance of 300 m. A number of key technologies were developed indigenously to accomplish this major feat, which included the use of indigenously developed NAVIC receiver for time synchronization between the transmitter and receiver modules, and gimbal mechanism systems instead of bulky large-aperture telescopes for optical alignment. he no-cloning theorem is a fundamental concept in quantum mechanics that states that it is impossible to create an exact, identical copy of an arbitrary unknown quantum state. In classical information theory, making copies of information is straightforward, and it is commonly done in everyday technologies like photocopiers. However, in the quantum realm, the situation is different due to the principles of quantum superposition and entanglement. The basics of quantum gates were also explained.

On Day 3 Dr.G.L.N.Murthy Professor of ECE department has introduced the Quantum signals. Classical signal processing and quantum signal processing are two different approaches to manipulating and analysing signals, where signals can be any form of information encoded in a physical quantity over time or space. Here are the key differences between classical and quantum signal processing. Converting a real-time signal into a quantum signal involves a process that is still an active area of research in quantum information processing. The basic idea is to encode the classical information carried by a real-time signal into a quantum state, often represented using qubit. This was followed by explaining basis encoding and amplitude encoding.

Quantum Encoding encodes the information into the quantum state of one or more qubits. The specific encoding method will depend on the nature of the signal and the requirements of the quantum processing task. Various steps in Quantum signal processing like superposition, Quantum Gates and Operations, Entanglement (Optional)Quantum Measurement, Classical Readout were briefly explained.

On Day 4 , Dr.Amit Kumar Datta from IIT Kharagpur has explored the foundations of Quantum signals though random processes. In quantum computing, Pauli gates are a set of

quantum logic gates that are based on the Pauli matrices, which are a set of three 2x2 complex matrices named after the physicist Wolfgang Pauli. Pauli gates are used to perform specific quantum operations on qubits, the basic units of quantum information. The coexistence of quantum and classical frameworks refers to scenarios where both quantum and classical systems or algorithms are utilized, often in conjunction, to address specific tasks or solve particular problems. This coexistence can take different forms and can be applied in various domains. In many practical scenarios, it may be challenging to fully leverage the power of quantum computers due to factors like decoherence and error rates. As a result, researchers and developers often design hybrid algorithms that combine quantum and classical components. These algorithms delegate certain tasks to a quantum processor while utilizing classical processing for other aspects. The distributed base station concepts were also explained briefly.

The overall Quantum signal processing system was elaborated on Day 5 by Dr.Amit, where it was mentioned that Hermitian matrix is the standard input to QSP system followed by subsequent systems. quantum signal processing involves the manipulation and analysis of quantum signals, which are quantum-mechanical systems representing information. Quantum computers have the potential to process quantum signals more efficiently than classical computers for certain tasks. Quantum gates are the basic building blocks of quantum circuits, allowing for the manipulation of qubits (quantum bits). Various gates, such as Hadamard gates, CNOT gates, and phase gates, are used in quantum circuits for signal processing tasks The session continued by exploring the work currently carried out in the Quantum domain.

Millimeter-wave (mmWave) beamforming is a technology used in wireless communication systems to enhance the performance of communication links, particularly in the context of 5G and beyond. While classical signal processing techniques are commonly used for mmWave beamforming, the application of quantum computing in this domain is an area of ongoing research and exploration.

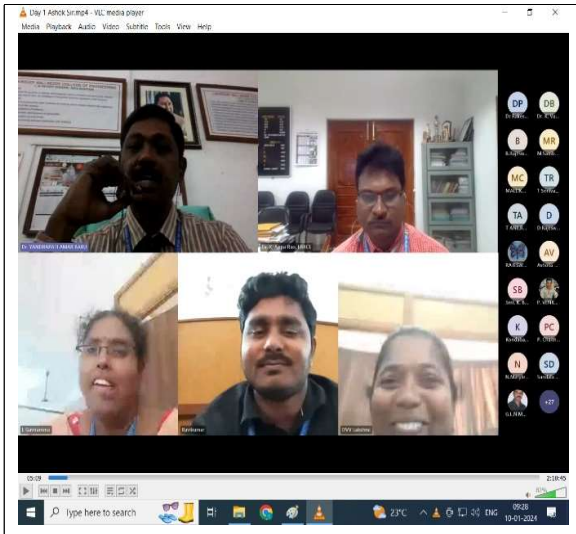
On Day 6, mathematical aspects of Quantum computing were elaborated by Dr.Alok Kumar Pan from IIT, Hyderabad. In quantum computing, Hermitian operators play a crucial role in the description and manipulation of quantum systems. A Hermitian operator is a type of linear operator that has certain mathematical properties, particularly when applied to quantum mechanics. In quantum mechanics, physical observables are associated with Hermitian operators. These operators represent measurable quantities such as position, momentum, energy, and spin. The eigenvalues of these operators correspond to the possible outcomes of measurements of the associated observables. The properties of Hermitian operators were also explained. Quantum nonlinearity refers to phenomena in quantum mechanics that deviate from

the behaviour predicted by classical physics, particularly in the context of superposition and entanglement.

Feedback/Suggestions:

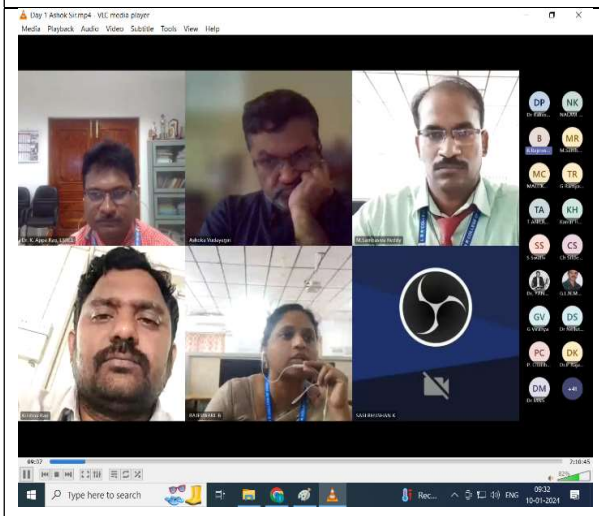
1. More number of sessions
2. Share video recordings
3. FDP on 5G
4. FDP on development tools for quantum logical processing

Photographs:

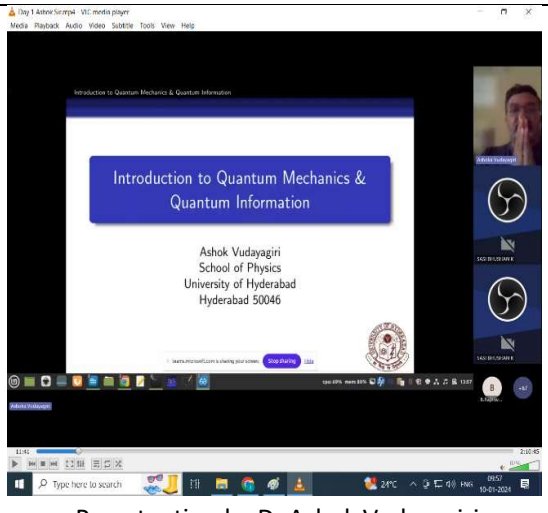


Addressing by Dr.Y.Amar Babu, Head of the department

Dr.K.Appa Rao, Principal, Addressing the Participants

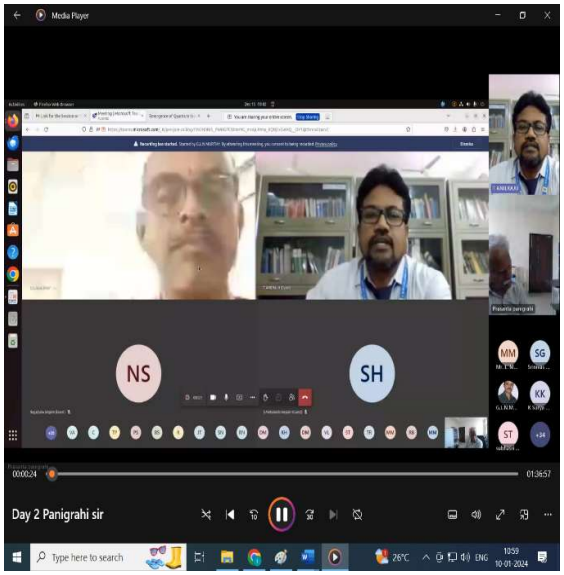


Mr.M.Samba siva Reddy, introducing the resource person, Dr.Ashok Vudayagiri

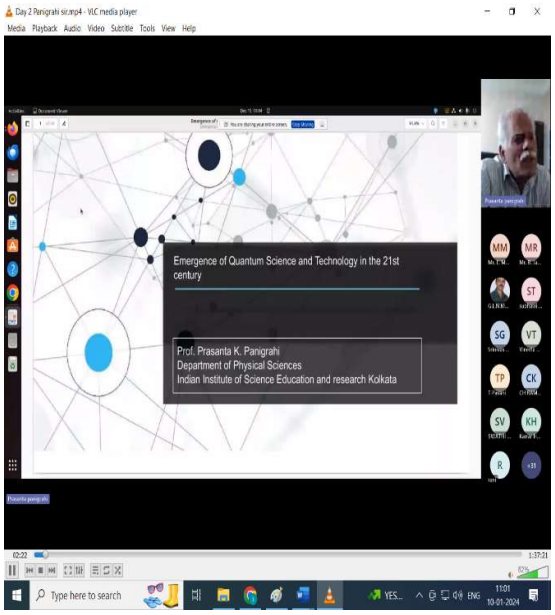


Presetnation by Dr.Ashok Vudayagiri

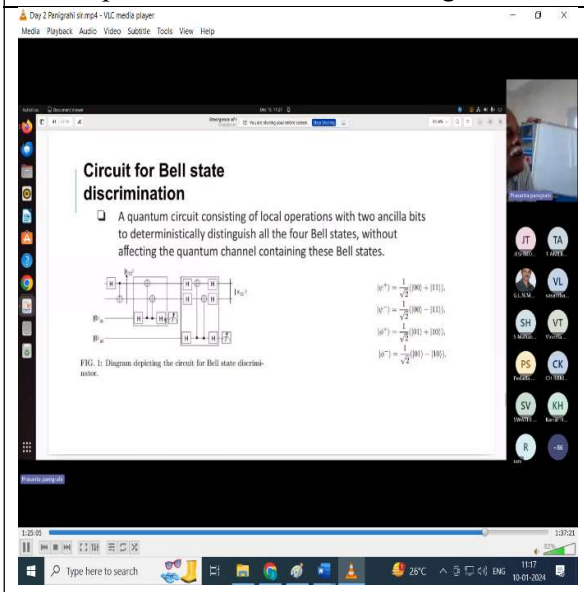
Day1 Proceedings



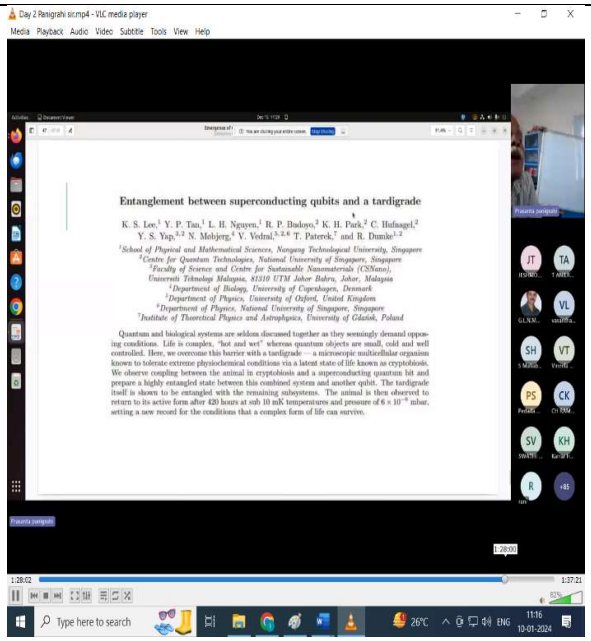
Mr.T.Anil Raju, introducing the resource person, Dr.Prasantha K Panigrahi



Presetnation by Dr.Prasantha K Panigrahi

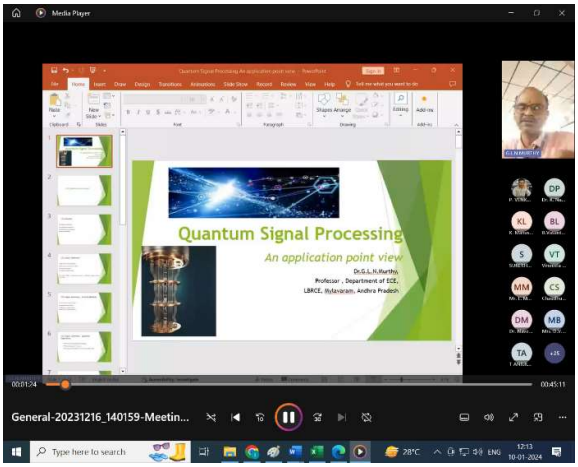


States in Quantum Computing

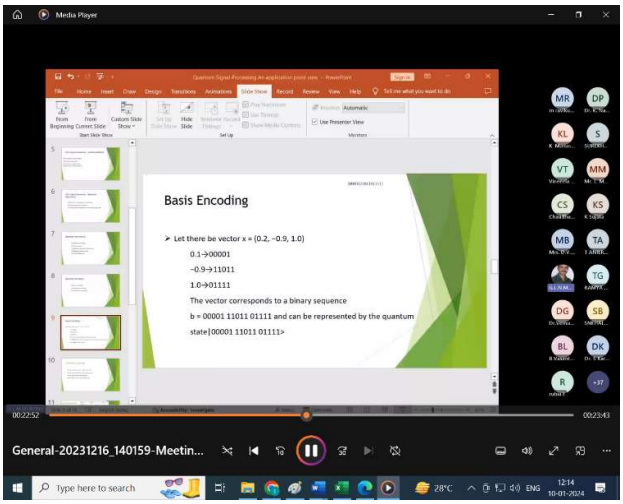


Progress of work in the Quantum area

Day 2 Proceedings

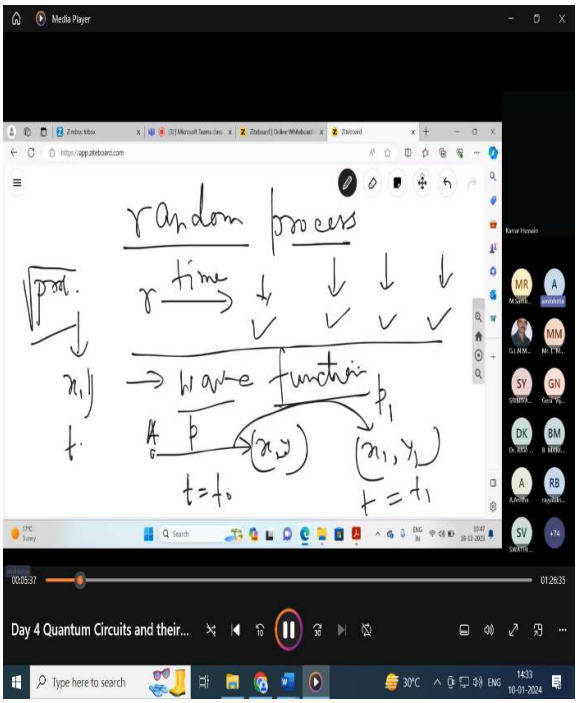


Session by Dr.G.LN.Murthy on Quantum signals

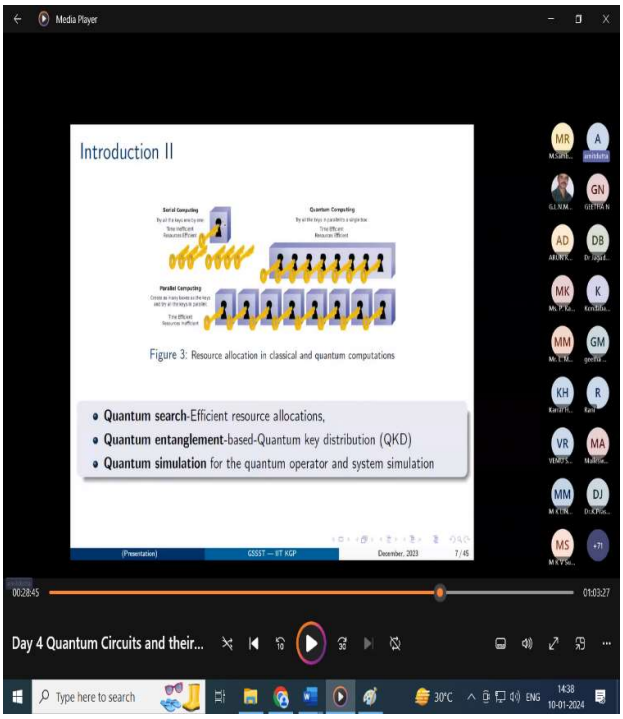


Encoding schemes for converting Classical Signal to Quantum Signal

Day 3 Proceedings

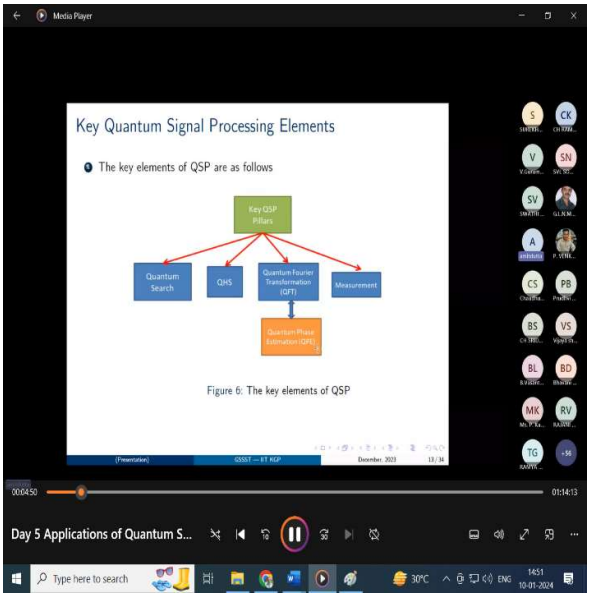


Session by Dr.Amit Kumar Datta on Quantum signals

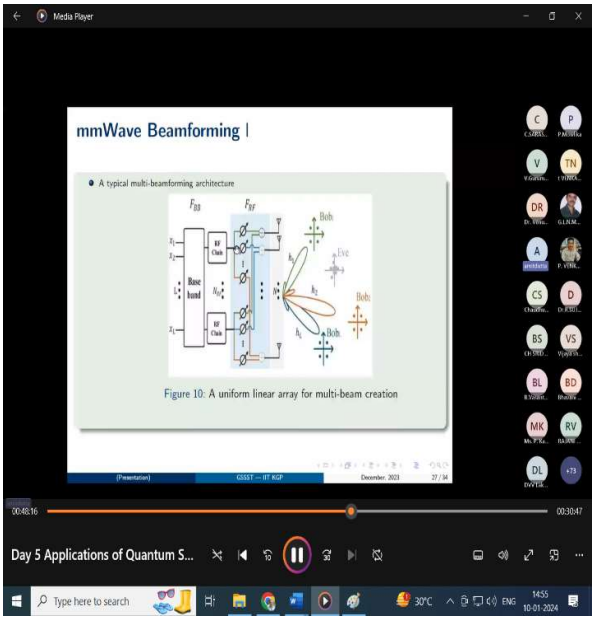


Pauli gates in Quantum signal Processing

Day 4 Proceedings

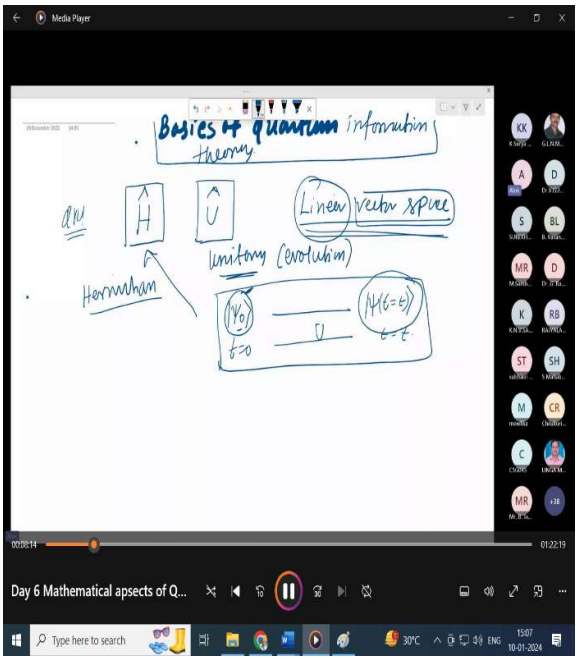


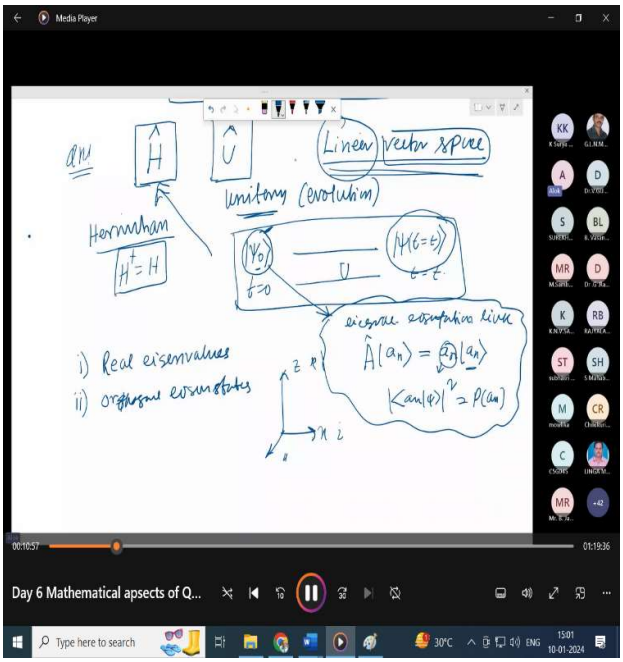
Session by Dr.Amit Kumar Datta on elements of a QSP System



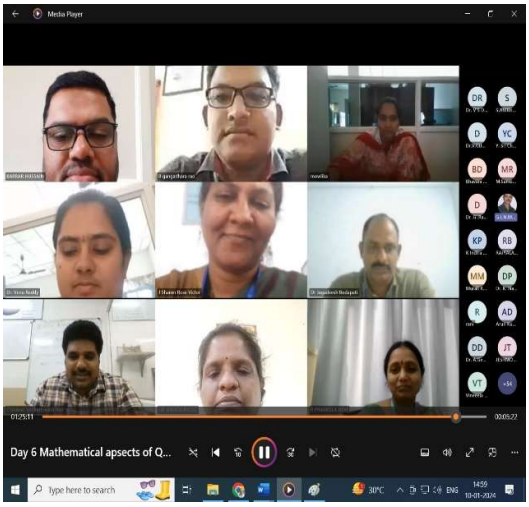
Quantum Processing mmWave beam forming

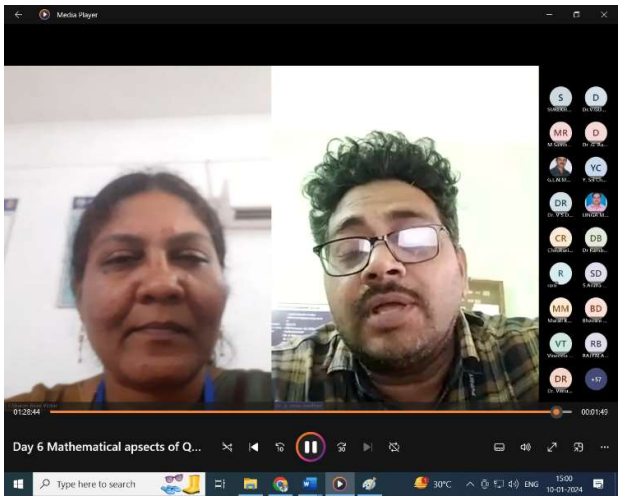
Day 5 Proceedings





Role of Hermitian operator by Dr.Alok Kumar Pan, IIT Hyderabad





Participants sharing their opinion on the Faculty Development program

Day 6 Proceedings