

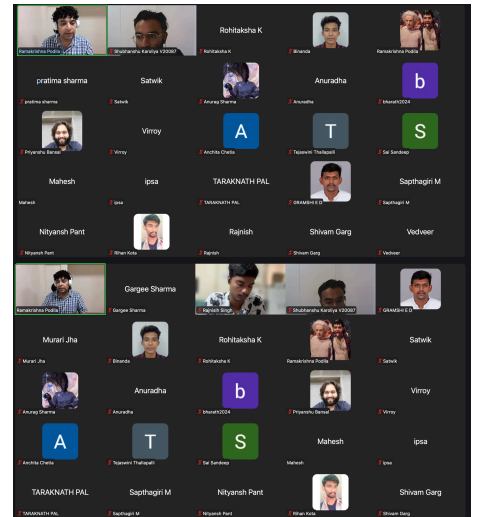
GIAN course conducted on Hands-on Quantum Computing and Quantum Information

- None of these can be written as a product state \Rightarrow **entangled**.
- Together they form the **Bell basis** for two-qubit states.
- Any two-qubit state can be expressed as a linear combination of them.

$$|00\rangle = \frac{1}{\sqrt{2}}(|\phi^+\rangle + |\phi^-\rangle).$$

Ramakrishna Podila Density Matrices in Quantum Information

Three-Qubit Examples: GHZ and W



A GIAN course on “Hands-on Quantum Computing and Quantum Information” was conducted online at the Indian Institute of Technology Delhi from 29 September to 10 October 2025, under the **Ministry of Education’s Global Initiative of Academic Networks (GIAN) program**.

The course was led by *Prof. R. Podila* (Department of Physics, Clemson University, USA) and *Prof. Gargee Sharma* (Department of Physics, IIT Delhi) and drew participants from across India, including students, faculty, and professionals from academia and industry.

- But, by **EPR(B)**, the measurement on particle 1 could not have caused particle 2 to acquire this property, for particle 2 was not disturbed in any way by the measurement on 1.
- Thus, if particle 2 is known to have this property after the measurement, it must evidently have possessed it all along, independent of the measurement made on particle 1. The measurement on 1, if/when performed, permits us to learn something about the z-axis spin of particle 2. But the fact we learn about, *exists* (i.e., is an element of reality) independent of that measurement.

change: i SWAP and \sqrt{i} SWAP

$\omega_1 = \omega_2$: coherent exchange in the single-excitation

$$U(t) = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(gt) & -i\sin(gt) & 0 \\ 0 & -i\sin(gt) & \cos(gt) & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}.$$

\sqrt{i} SWAP (entangling).
iSWAP.

The program offered a comprehensive introduction to quantum computing and quantum information, covering quantum mechanics fundamentals, quantum gates and circuits, quantum algorithms (Deutsch, Grover, Shor), and quantum cryptography (BB84 protocol). Participants also gained hands-on experience using IBM Qiskit for implementing and visualizing quantum circuits.