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Dr. Syed Salman Ahmad Warsi is an accomplished physicist, academician, and educator with extensive expertise in condensed matter physics. He currently serves as an Associate Professor in the Department of Physics at Integral University, Lucknow, and brings more than 25 years of experience in teaching, research, and academic mentorship.

Throughout his academic career, Dr. Warsi has taught undergraduate and postgraduate students, making significant contributions to physics education through his dedicated teaching and research guidance. He has successfully supervised numerous B.Sc. and M.Sc. dissertations and projects and is actively involved in mentoring doctoral scholars pursuing Ph.D. research in Physics.

His research interests include liquid-crystal systems, nanoscale materials, and contemporary topics in condensed matter physics. Dr. Warsi has published several peer-reviewed research papers in reputed journals and continues to contribute actively to scientific research and academic development.

In addition to his research contributions, Dr. Warsi has co-authored important educational books, including:

- *ICSE Physics for Class X (2025)*
 - *ISC Practical Physics for Classes XI & XII (2021)*
- He has also served as editor of the following scholarly books:*
- *Characterization of Liquid Crystals and Photonic Crystals (2022)*
 - *Advances in Contemporary Physics: High Energy, Cosmology and Soft Matter (2025)*

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CHAPTER - 5

QUANTUM ENTANGLEMENT: FROM CONCEPTUAL ORIGINS TO PRACTICAL APPLICATIONS

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Quantum entanglement is one of the most fundamental and intriguing phenomena in quantum mechanics, revealing correlations between quantum systems that cannot be explained by classical physics. This chapter presents a comprehensive overview of the conceptual foundations, theoretical framework, experimental realization, and technological applications of quantum entanglement. Beginning with the historical debates initiated by Einstein, Podolsky, Rosen, and Schrödinger, the discussion highlights the emergence of entanglement as a central feature of quantum theory and its connection to non-locality through Bell's theorem. The mathematical formalism of entangled states, including Hilbert spaces, tensor products, Bell states, density matrices, and entanglement entropy, is introduced to provide a rigorous theoretical understanding. The chapter further examines experimental verification through spontaneous parametric down-conversion and Bell inequality tests, including recent loophole free experiments. In addition, current developments in India, such as the National Quantum Mission and satellite-based quantum communication initiatives, are discussed. Major applications of entanglement in quantum communication, quantum teleportation, quantum computing, and quantum networks are reviewed, emphasizing their transformative potential for future technologies. Finally, the chapter outlines ongoing challenges and future prospects, highlighting the crucial role of entanglement in the development of next-generation quantum systems and the emerging quantum internet.

INTRODUCTION:

Quantum mechanics represents one of the most profound revolutions in the history of science, fundamentally altering our understanding of the physical universe. Unlike classical physics, which is based on determinism and locality, quantum mechanics introduces