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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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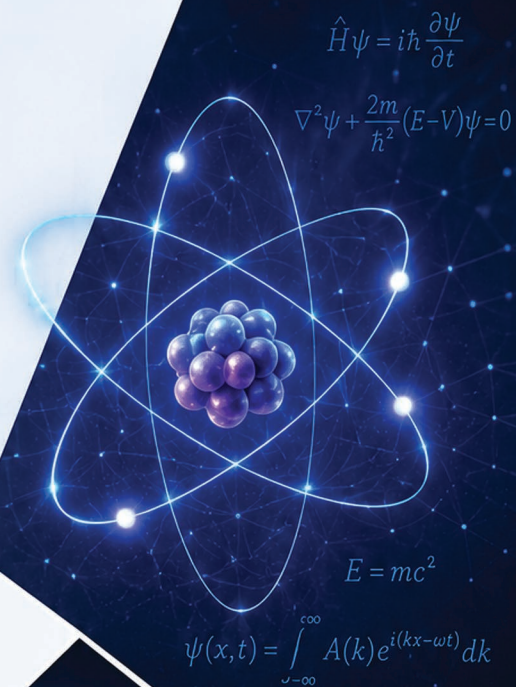
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CHAPTER - 6

FUNCTIONAL MAGNETIC NANOPARTICLES: SYNTHESIS, CHARACTERIZATION AND APPLICATIONS

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This chapter provides a comprehensive introduction to functional magnetic nanoparticles (MNPs), emphasizing their fundamental magnetic behavior, synthesis strategies, characterization techniques, and multidisciplinary applications. The discussion begins with the physics of nanoscale magnetism, including single-domain formation, superparamagnetism, magnetic anisotropy, and blocking temperature. Various synthesis approaches such as co-precipitation, thermal decomposition, hydrothermal, sol-gel, and vapor-phase methods are presented, along with the importance of surface functionalization for enhancing stability and functionality. The chapter further reviews advanced characterization techniques including X-ray diffraction, electron microscopy, scattering methods, magnetometry, and thermal analysis for understanding structure-property relationships. Finally, major applications of MNPs in spintronics, catalysis, environmental remediation, magnetic resonance imaging, targeted drug delivery, hyperthermia, bio-sensing, energy storage, and smart materials are highlighted. The chapter aims to provide a clear and interdisciplinary understanding of the scientific principles and technological significance of functional magnetic nanoparticles.

INTRODUCTION:

Magnetic nanoparticles (MNPs) are nanoscale systems (1–100 nm) in which finite-size effects and large surface-to-volume ratios significantly modify magnetic behavior compared to bulk materials. At these dimensions, magnetic properties are governed by the interplay between exchange interactions, magnetic anisotropy, and thermal fluctuations, leading to phenomena such as single-domain formation and superparamagnetism [1].