

ADVANCES IN CONTEMPORARY PHYSICS

HIGH-ENERGY, COSMOLOGY,
AND SOFT MATTER



Dr. Syed Salman Ahmad Warsi

Advances In Contemporary Physics

High-Energy, Cosmology, and Soft Matter

Dr. Syed Salman Ahmad Warsi

Associate Professor

Department of Physics

Integral University, Lucknow



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List of Contributors

1. Dr. Salman Ahamad Khan

Department of Physics, Integral University, Lucknow, 226026, India

2. Dr. Mohd Shahalam

Department of Physics, Integral University, Lucknow, 226026, India

3. Muskan Khan

Department of Physics, Integral University, Lucknow, 226026, India

4. Dr. Syed Salman Ahmad Warsi

Department of Physics, Integral University, Lucknow, 226026, India

5. Dr. Afroj A. Khan

Department of Physics, Integral University, Lucknow, 226026, India

6. Dr. Seema Srivastava

Department of Physics, Integral University, Lucknow, 226026, India

7. Dr. Vipul Srivastava

Department of Physics, Lovely Professional University, Phagwara, India

8. Dr. Ghizal F. Ansari

Department of Physics, Madhyanchal Professional University, Bhopal, India

9. Dr. Ghazala Roohi Fatima

Department of Physics, Babu Banarasi Das University, Lucknow, 226028, India

10. Dr. Shweta Srivastava

*Department of Chemistry, B.N. College of Engineering and Technology,
Lucknow*

11. Anjali Awasthi

Department of Physics, Babu Banarasi Das University, Lucknow, 226028, India

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FERROELECTRICITY IN LIQUID CRYSTALS AND ITS APPLICATIONS

Syed Salman Ahmad Warsi

Department of Physics, Integral University, Lucknow, 226026, India

This chapter offers a thoughtful overview of ferroelectric liquid crystals (FLCs), guiding readers through their journey from initial discovery to their current role in cutting-edge display technologies. It begins by introducing the basic physical concepts behind ferroelectricity in liquid crystals, particularly focusing on how chirality and layered molecular arrangements in chiral smectic phases give rise to their unique behavior. These materials stand out for their spontaneous polarization, rapid response, and bistable states—features that make them ideal candidates for high-performance display applications. We then revisit some of the key breakthroughs in the field, especially the development of the surface-stabilized ferroelectric liquid crystal (SSFLC) configuration in the 1980s. This innovation marked a turning point by addressing alignment challenges and unlocking the potential for practical, stable devices. The chapter also explores more recent advancements, including efforts to fine-tune material properties, optimize alignment layers, and develop driving schemes that support fast switching and smooth gray scale rendering. In closing, we highlight how ongoing research continues to push the boundaries of what FLCs can do, positioning them as vital components in the future of responsive and energy-efficient display technologies.

INTRODUCTION:

Ferroelectricity, as it is traditionally understood in solid-state systems, is largely absent in conventional liquid crystals due to the inherently weak dipole-dipole interactions among their constituent molecules. Unlike solid ferroelectric materials that exhibit spontaneous electric polarization reversible by an external electric field, liquid crystal molecules typically exhibit orientational order rather than positional order. This means that while the long axes of these molecules tend to align along a preferred direction, known as the *director* (denoted as \mathbf{n}), they still possess a degree of angular distribution around this axis. This angular dispersion plays a critical role in defining the *order parameter*, which quantifies the extent of molecular alignment within the liquid crystalline phase [1, 2].

Furthermore, although many liquid crystal molecules possess intrinsic dipole moments, their bulk structures usually maintain an *up-down symmetry* (i.e., symmetry between \mathbf{n} and $-\mathbf{n}$ directions). This symmetry negates the possibility of a net polar alignment in most common liquid crystal phases, thus precluding the emergence of ferroelectricity under normal conditions.