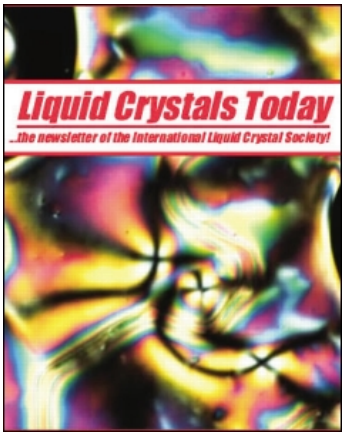

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One- and two-dimensional fluids

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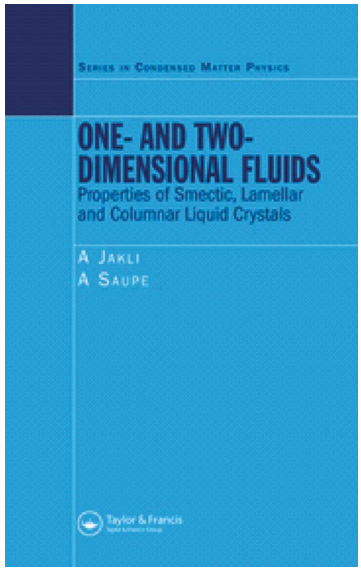
Book Review

One- and two-dimensional fluids

Properties of smectic, lamellar and columnar liquid crystals by A. Jákli and A. Saupe, Boca Raton, FL: CRC Press, 2006, 352pp., US$139.46 (hardback), ISBN: 978-0-7503-0969-1 or 0-7503-0969-5

To be frank from the beginning, I really like this book. It avoids the sometimes artificial boundaries between thermotropic and lyotropic phases, as well as those of different types of mesogens, may they be calamitic, bent-core, discotic or bowlic. General concepts are introduced by means of liquid crystal phases, and topics are discussed which often do not find their way into the standard texts about our subject, one example being soap films, which are often treated separately from liquid crystals.



In contrast to many of the books on liquid crystals to date, the present text does not introduce phases and properties via the molecular building blocks, but rather properties are discussed in terms of the structure and geometry of phases. As such, it is not primarily of importance if a layered phase is formed through change in temperature or addition or removal of a solvent, or if a columnar phase consists of disc-like, swallow-tailed or bent-core mesogens. This text introduces the main properties of low-dimensional fluids such as elasticity, flow and optics, as well as electric and magnetic behaviour, in terms of phase structure, not molecular species. There is a good balance between theory and experiment, and the figures are detailed and illustrative, although a few of them would have profited from colour reproduction: for example, the Michael–Levi chart in the discussion of birefringence.

The first chapter intuitively introduces the different phases, thermotropics and lyotropics, as well as micells, chromonics and amphotropics, already indicating the diversity of materials covered. In addition, chiral variants are discussed. Low-dimensional fluids are then discussed in terms of surface tension, introducing Langmuir–Blodgett films and the minimal surfaces of soap films in detail, as well as membranes and free-standing films. The following chapter gives a general introduction to phase transitions between partially ordered fluids, outlining the main points of the fundamental theories of Landau, Onsager and Maier–Saupe.

After the introductory chapters, the text concentrates on a range of different physical properties, starting with rheology and elasticity whereby nematic, cholesteric and fluid smectic phases (smectic A and smectic C) are discussed alongside lyotropic phases and soap membranes. Optical properties are outlined mainly for the nematic phase, but also including its chiral variant by discussing the optics of helical media such as the cholesteric phase. Some experimental techniques are introduced for the study of birefringence, and conoscopy is briefly demonstrated for uniaxial media. In this context, it would also have been worthwhile to see a more detailed discussion of biaxiality, for example of a biaxial smectic C phase.

The optical properties of liquid crystals, together with the fact that the elastic constants of these materials are very small as compared with solid state matter, makes the observation of defect structures easy and illustrative. Some of these defect structures, such as the Schlieren defects and vortex defects in nematics, are discussed. Also, defects in lyotropic phases, smectics and lamella structures are introduced, including ferroelectric liquid crystals and banana phases with characteristic chevron structures and zigzag defects. Personally, I think that this chapter could have been a bit more detailed, especially as there appears to be no modern, exhaustive account of defect structures in liquid crystals available in the literature. For example,

in the discussion of the cholesteric oily streaks defects a schematic representation would have been helpful; also, the twist grain boundary and blue phases perhaps deserved slightly more attention. The possibility of the annihilation of defects is mentioned, as is the existence of an attractive force between defects of opposite sign, but no examples concerning the actual defect annihilation dynamics are given, which are of interest beyond liquid crystalline phases. Defects and defect arrays observed under confinement in capillaries are discussed, but defects surrounding micron-sized particle inclusions, and their respective interactions, are unfortunately not talked about.

The magnetic and electric properties are introduced via the interaction of respective fields with the liquid crystalline materials, i.e. via the traditional Freedericksz transition, the Cotton–Mouton effect, electric conductivity and the concepts of piezoelectricity, flexoelectricity and ferroelectricity. Some measurement techniques are introduced, specifically dielectric spectroscopy, which is also elaborated on in one of the appendices. Given the importance of ferroelectric liquid crystals in fundamental research, being the only fluid ferroelectric materials currently in existence, I believe that the discussion of these materials could have been more detailed, also in relation to the method of dielectric spectroscopy, separating collective and molecular modes. The discussion of the electric properties of columnar phases and those of bowlic and bent-core molecules is brief. Given the research efforts over the last decade, especially in the field of discotic liquid crystals as one-dimensional conductors, it is surprising that this aspect was not covered in more detail.

The concluding chapter focuses on the applications of liquid crystals; standard display devices, spatial light modulators, a short excursion into optical communication and photonics (limited to the selective reflexion of cholesterics), as well as lyotropics and life. Call me cynical, but I have the impression that this chapter is only included because tradition tells us to advertise and justify liquid crystal research through its application aspects. I feel that this chapter does not really fit into the otherwise very appealing general concept of the book, which is to introduce the fundamental properties of low-dimensional fluids irrespective of the traditional borders between sub-fields in liquid crystal and soft matter research.

To give a general conclusion, please let me repeat myself, I really like this book. Antal Jákli and the late Alfred Saupe have compiled a refreshing new introduction to the properties of liquid crystals and related soft matter systems by looking beyond the traditional sub-fields of this research area and by bringing together thermotropic calmitic and discotic phases with lyotropic phases and more exotic structures. I will certainly recommend this book for my soft matter physics course, and I believe that this text should be on the shelves of every library of research groups concerned with any aspect of liquid crystals research.

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