Richard M. Hornreich

Anisotropic Fluids

Born 1938 in New York, USA. B.S. (1958), M.S. (1959), Elect. Eng. (1961) from Massachusetts Institute of Technology, Cambridge, MA und Ph.D. (1967) from Weizmann Institute of Science, Rehovot, Israel. Since 1978, Prof. of Condensed Matter Physics at Weizmann Institute. Dean, Feinberg Graduate School, 1984-1989. Previous sabbaticals at Yale University, New Haven, CT, and IBM Zurich Research Center in 1976-77, and at Imperial College, London, and Oxford University in 1983-84. More than 100 publications in magnetism, statistical physics, and physics of liquid crystals. Address: Department of Electronics, The Weizmann Institute of Science, Rehovot 76100, Israel.

My research interests are in theoretical condensed matter physics, particularly the physics of anisotropic fluids (e. g., liquid crystals) and statistical mechanics. My research activities at the Wissenschaftskolleg were primarily in the former area. Among the problems I considered during the year were:

1. The structures and properties of *cholesteric Blue Phases.* These unusual phases have been the subject of intensive theoretical and experimental studies over the past decade and their behavior is, in general, now well-understood. However, one of them, *Blue Phase III* (also known as the *`fog"* phase) is still very much a puzzle, not even its structure is known. Several theoretical models have been proposed over the years but all were found to be lacking in essential elements. I decided to consider a new approach, in which a fundamental role ist ascribed to topological singularities (dislocations). These have been shown to be a key element in understanding special phases in two-dimensional systems and there are indications that they could also be of importance in the case of three-dimensional *Blue Phase III.* Although the theoretical calculations have proved to be very difficult, the basic requirements for such an approach are now clear and I shall be continuing with this work.

2. A common theme, when a model is intractable, is seeking a simpler one which *(a)* still has the essential features of the more complex one, and *(b)* is solvable. Given the difficulties of the three-dimensional *Blue Phase*

III problem, I sought an alternative that would, on the one hand, have some three-dimensional features and, on the other, permit me to utilize techniques which give solutions for two-dimensional systems. This led me to consider a system of non-magnetic particles suspended in a ferrofluid (i. e., a paramagnetic liquid). Such a system, due to the nature of the interactions, has properties which are intermediate between two and three dimensions.

The case of particular interest was one in which the particles have elongated (i. e., prolate ellipsoidal) rather than spherical shapes. Here there is the possibility of a "partially melted state", wherein translational but not orientation order is lost. Such a state could be analogous to *Blue Phase III. I* have begun a theoretical study of the melting of such arrays of "anisotropic magnetic holes". Since melting is still one of the most poorly understood universal phenomena in condensed matter physics, this study should help to improve our understanding of this subject and perhaps provide a key to future studies on truly three-dimensional systems.

3. Spiral director configurations occur when cholesteric liquid crystals are confined between two parallel plates with the director (which defines the direction of local order) fixed in the film plane at the boundaries. Such states, however, become unstable when a field applied normal to the film exceeds a critical value. Together with a student, Guy Cohen, I have studied the instability modes appearing at such *generalized Fréedericksz instabilities.* In particular, the case in which the instability mode character changes from uniform to non-uniform (i. e., with one-dimensional stripes) in the film plane was considered. Points on such a surface can have unique properties, in which case they are known as *Lifshitz multicritical points.* This work has been submitted to the journal *Physica* A.

4. As a result of a joint experimental project by researchers at the Technische Universität Berlin and the University of Hawaii, I became interested in the transient response of cholesteric *Blue Phases* to applied fields. In particular, their experimental data showed that two relaxation processes were involved, with very different characteristic times (differing by a factor of more than 10000!). A colleague, Shmuel Strikman, and I have developed a theoretical model which successfully explains these results, showing them to be due to a very rapid polarization of the local director followed by a much slower relaxation of the cholesteric pitch. A manuscript covering this work is now being prepared for publication.

5. Additional activities:

A two day workshop on *Cholesteric Blue Phases* was held at the Wissenschaftskolleg in December 1989.

An invited lecture on *Ripple Instability Modes in Cholesteric Films* was given at the workshop on *Order in Fluids* held at the Technische Universität Berlin, February 1990.

An invited lecture on *Recent Developments in Cholesteric Blue Phases* was given at the Annual Meeting of the Condensed Matter Division of the German Physical Society in Regensburg, March 1990.

Seminars were given at Universität Stuttgart, Universität Kiel, and the Humboldt Universität Berlin.