

What is the Director?

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The concept of the director for uniaxial phases permeates all of liquid crystal science and technology. However, the term is understood in a variety of ways and has different meanings and definitions. The word *director* was introduced by Albert Green to describe a vector field in the continuum theory of complex fluids [1]. The term is now widely used in the continuum theory of liquid crystals, both static and dynamic. The director is described, somewhat loosely, as the preferred direction of the constituent molecules. This definition can be imprecise because the axis that is aligned needs to be identified. Thus for rod-like molecules the aligned axis is associated with the molecular long axis which cannot be uniquely defined. Indeed, as the structures of the mesogenic molecules have become more complicated and have departed from a simple rod-like form the identification of the molecular axis with which to identify the director has become more problematic. This difficulty is compounded by the inherent molecular flexibility which results in numerous conformations with different shapes and symmetries.

This problem was appreciated by Sir Charles Frank who proposed an alternative definition of the director in terms of a tensorial property of the phase, such as the diamagnetic susceptibility. He argued that the director would correspond to the principal axis for the largest component of this second rank tensor; an approach adopted earlier by Victor Tsvetkov [2, p 371] but for different reasons. In addition, the two remaining principal components would be equal which, according to the Neumann Principle, requires the phase to have a three-fold or higher rotation axis about the director. It might be expected that the precise location of the director would depend on the choice of the property but this is not the case when the phase possesses such a symmetry axis. Of course, when the constituent molecules are rigid with $D_{\infty h}$ symmetry the nematic phase is expected to possess an infinite rotation axis. This is to be identified with the director and can be located from the Saupe ordering matrix for the molecular symmetry axis in the laboratory frame.

The situation becomes more complex and interesting when the mesogenic molecules are biaxial with, say, D_{2h} symmetry. Now there is the expectation of a biaxial nematic phase also with the same symmetry. This will possess three orthogonal directors which can be identified from the second rank ordering supertensor or from the Frank strategy. Thus the magnetic susceptibility tensor will be diagonal in the frame containing the three directors and, as de Gennes has noted, the principal components will provide a measure of the relative phase biaxiality [3]. The phase behaviour becomes even more interesting when the molecules have a symmetry lower than D_{2h}

for a range of biaxial nematics becomes possible. The Frank strategy certainly gives the three orthogonal principal axes of the magnetic susceptibility tensor but to what extent these can be identified as the directors is no longer apparent. Possible solutions to defining and locating the directors as well as characterising the phases are considered including the representation of the orientational order in a space of higher dimension.

References

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- [2] F. C. Frank, *Proceedings 9th International Liquid Crystal Conference Bangalore, 1982.*
- [3] P. G. de Gennes *The Physics of Liquid Crystals* (Clarendon Press, Oxford, **1974**) p 32.