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Field Theories in Chiral Liquid Crystals: A Theory for Helicoids and Skyrmions

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Abstract : The work is focused on determining and comparing special nonlinear static configurations in cholesteric liquid crystals (CLCs), confined between two parallel plates and in the presence of an external static electric/magnetic field. The solutions are stabilised by topological and non-topological conservation laws since they are described in terms of integrable or partially integrable nonlinear boundary value problems. In cholesteric liquid crystals which are subject to geometric frustration; anchoring conditions at boundaries, i.e., homeotropic conditions, are incompatible with the cholesteric twist. This aspect turns out to be essential in the admissible classes of solutions, allowing also for disclination type singularities. Within the framework of Frank-Oseen theory, we study the static configurations for CLCs. First, we find numerical solutions for isolated axisymmetric states in confined CLCs with weak homeotropic anchoring at the boundaries. These solutions describe 3-dimensional modulations, namely spherulites or cholesteric bubbles, actually observed in these systems, of standard baby skyrmions. Relations with well-known nonlinear integrable systems are found and are used to explore the asymptotic behavior of the solutions. Then we turn our attention to extended periodic static configurations called Helicoids or cholesteric fingers, described by an elliptic sine-Gordon model with appropriate boundary conditions, showing how their period and energies are determined by both the thickness of the cell and the intensity of the external electric/magnetic field. We explicitly show that helicoids with π or 2π of rotations of the molecular director are different in many aspects and are not simply algebraically related. The behaviour of the solutions, their energy and the properties of the associated disclinations are discussed in detail, both analytically and numerically.

Keywords : cholesteric liquid crystals, geometric frustration, helicoids, skyrmions
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