Dynamics and bifurcations in the weak electrolyte model for the nematic liquid crystals electroconvection: a Ginzburg-Landau approach

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ABSTRACT

We present the results of a bifurcation study of the weak electrolyte model for nematic electroconvection, for values of the parameters including experimentally measured values of the nematic I52. Nematic liquid crystals are charge carrying fluids with long range, uniaxial orientation and molecular alignment, giving rise to anisotropic macroscopic properties. The external electric field causes the instability of the equilibrium state, leading to electroconvective motion. The weak electrolyte model consists of partial differential equations for the velocity field, the director, the electrical potential and charge, derived from the Navier Stokes equations for an anisotropic electrically conducting fluid, the conservation of charge, Poisson law and a partial differential equation for the conductivity.

The linear stability analysis shows the existence of primary bifurcations of Hopf type, involving normal as well as oblique rolls. The weakly nonlinear analysis is performed using four globally coupled complex Ginzburg-Landau equations for the waves' envelopes. If spatial variations are ignored, these equations reduce to the normal form for a Hopf bifurcation with $O(2) \times O(2)$ symmetry. A rich variety of stable waves, as well as more complex dynamics, including quasiperiodic solutions, heteroclinic cycles and chaos is predicted at onset. Corresponding complex spatiotemporal dynamics, including spatiotemporal chaos, intermittency and a temporal period doubling route to spatiotemporal chaos through a period doubling cascade towards a chaotic attractor in the normal form, is identified in the numerical simulation of Ginzburg Landau equations. Eckhaus stability boundaries for travelling waves are also determined. The methods developed in this paper provide a systematic investigation of nonlinear physical mechanisms generating the patterns observed experimentally, and can be generalized to any two-dimensional anisotropic systems with translational and reflectional symmetry.