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Convergent finite element methods for the Ericksen model of nematic liquid crystals

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The Ericksen model describes nematic liquid crystals (LCs) in terms of a unit-length vector field (director) and a scalar function (degree of orientation). Compared to the classical Oseen-Frank model, it allows for the description of a larger class of defects. Equilibrium states of the LC are given by admissible pairs that minimize an energy functional, which consists of the sum of Oseen-Frank-like energies and a double well potential. The resulting Euler-Lagrange equations are degenerate for the director, which poses serious difficulties to formulate mathematically sound algorithms for their approximation. We propose a simple but novel finite element approximation of the problem that does not employ a projection to impose the unit-length constraint on the director and thus circumvents the use of weakly acute meshes, quite restrictive in 3D. We show stability and Gamma-convergence properties of the new method in the presence of defects. We also discuss an effective nested gradient flow algorithm for computing minimizers that controls the violation of the unit-length constraint. We present several simulations in 2D and 3D that document the performance of the proposed scheme and its ability to capture quite intriguing defects. This is joint work with Ricardo H. Nochetto (University of Maryland) and Shuo Yang (BIMSA).

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