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A universal thin film model for Ginzburg-Landau energy with dipolar interaction

We present an analytical treatment of a three-dimensional variational model of a system that exhibits a second-order phase transition in the presence of dipolar interac- tions. Within the framework of Ginzburg-Landau theory, we concentrate on the case in which the domain occupied by the sample has the shape of a flat thin film and obtain a reduced two-dimensional, non-local variational model that describes the ener- getics of the system in terms of the order parameter averages across the film thickness. Namely, we show that the reduced two-dimensional model is in a certain sense asymp- totically equivalent to the original three-dimensional model for small film thicknesses. Using this asymptotic equivalence, we analyze two different thin film limits for the full three-dimensional model via the methods of Γ-convergence applied to the reduced two- dimensional model. In the first regime, in which the film thickness vanishes while all other parameters remain fixed, we recover the local two-dimensional Ginzburg-Landau model. On the other hand, when the film thickness vanishes while the sample's lateral dimensions diverge at the right rate, we show that the system exhibits a transition from homogeneous to spatially modulated global energy minimizers. We identify a sharp threshold for this transition.