Field-induced layer thinning transition in free-standing smectic films

M. S. S. Pereira, I. N. de Oliveira, M. L. Lyra

Instituto de Física, Universidade Federal de Alagoas, 57072-970 Maceió AL, Brazil.

Free-standing smectic films present unusual physical properties which are associated to surface and finite size effects. In particular, it has been observed that the surface anchoring stabilizes the smectic order well above of the bulk transition temperature. As a result, a great variety of phenomena can be observed in thin smectic films such wetting transitions, specific heat anomalies and the thickness dependence of the transition temperature. As the film thickness may vary from a few nanometers to several micrometers, free-standing films constitute an ideal setup to investigate the crossover from two-dimensional (2D) to three-dimensional behavior (3D). An interesting and unusual surface induced phenomenon in free-standing smectic films is the layer thinning transition which consists of a stepwise reduction of the film thickness as the temperature is raised above of the bulk transition temperature. X-ray scattering and optical reflectivity measurements have shown that the film thickness reduction is associated to the enhancement of smectic fluctuations in the central layers and the spontaneous formation of dislocation loops. So far, layer thinning transitions may be described by a simple power law expression $N(t) \propto t^{-\nu}$, where N is the number of layers and t is the reduced temperature. In this work, we have studied the field-induced layer thinning transitions in free-standing smectic films below to smectic-isotropic phase transitions by using a extended McMillan model. For films with a negative dielectric anisotropy, we observe that the external field induces a stepwise reduction of the film thickness similar to the original thinning transition. In particular, we notice that the thickness reduction obeys a simple power law expression $N(\xi) \propto \xi^{-\eta}$, where ξ is a reduced external field. However, the characteristic η exponent depends on the the film temperature. Further, we obtain the local nematic and smectic order parameter profiles for film under different strength of the surface anchoring and external field.