VAN DER WAALS AND STRUCTURAL FORCES: STABILITY OF THIN LIQUID-CRYSTALLINE FILMS

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In restricted geometry the macroscopic order of confined liquid crystals can be strongly affected by the confining walls resulting in an inhomogeneous order and/or deformation of corresponding director fields. The deformed order as well as its effect on the spectra of thermal fluctuations gives rise to the force between the confining walls known as structural force [1]: the deformed order gives rise to the mean-field force whereas the first correction to that order, i.e., harmonic fluctuations, gives rise to pseudo-Casimir force. In addition to structural force there is also the force caused by thermal fluctuations of the instantaneous electric dipoles of the constituting molecules – dispersion force – which is usually termed as van der Waals force [2]. In liquid crystals the total force between the confining walls depends strongly on the delicate properties of the confinement, however, in highly frustrated geometries and in the vicinity of phase transitions the structural forces are far from being negligible and thus, play an important role in (de)stabilization of the order and in the mechanical stability of the film itself.
In our study of the van der Waals force we have shown that in anisotropic liquids the known approximate Hamaker formulas for the van der Waals force can lead to incorrect results; either to wrong magnitude of the force or even to its wrong character (attraction/repulsion). We have derived similar simplified formulas which take into account the anisotropic nature of the permittivity tensor and refractive indices of interacting media. However, when trying to explain experiments one should be aware of the possible non-controlable formation of additional layers such as layers of water condensing from the atmosphere or oxide layers on solid substrates, which can have strong effect on the original force. The additional layers complicate the determination of van der Waals force and require the full analysis of the system instead of the simplifed combining of Hamaker constants. We will present the quality of different approximate formulas by comparing them to the results we have obtained in the full analysis.
We have employed the improved determination of van der Waals force in the study of stability of liquid-crystalline systems in planar geometry. The systems differed with respect to anchoring properties of the confining walls yielding different range and type of deformations of the bulk liquid-crystalline order and therefore also different strength, character, and range of the structural and van der Waals force. We were mostly interested in thin nematic depositions on solid substrates close to the nematic-isotropic or nematic-smectic phase transitions. We have determined the force between the solid substrate and the nematic-isotropic or nematic-smectic interface which is important in the process of growing of the wetting layer on approaching the phase transition.

References:

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