Smectic-A Elastomers Under Shear

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The response of smectic-A elastomers under uniaxial mechanical fields has been investigated intensively over the last years. Nishikawa et al. found a breakdown of the macroscopically oriented layer structure under strain imposed along the layer normal.[1]
This reorientation was theoretically interpreted as a layer undulation or rotation, where director and layer normal are rigidly locked together.[2,3] However, in chiral smectic-A* elastomers the director and the layer normal can be manipulated independently by applying electrical fields and as a consequence of the electroclinic effect a macroscopic shear has been observed.[4] Therefore, Stenull and Lubensky generalized the neoclassical theory of rubber elasticity of smectic-A elastomers under deformation along the director, allowing relative rotations of the director and the layer normal. The theory implied, that shear imposed in the layer planes should induce a smectic-C like tilt of the molecules.[5] Together with Adams and Warner they expanded their theory for shear deformations.[6] Recently, we could show that under certain circumstances this tilt can be observed.[7]
We present detailed X-ray experiments under shear strain perpendicular to the initial layer normal. We investigated smectic-A networks of different chemical constitution and found different responses to shear strain depending on specific elastic constants of the material. For networks with a large B-modulus an induced smectic-C like tilt is found in a good agreement with the theoretical predictions. For softer smectics with a lower B-modulus additional layer rotations are observed. Moreover we studied the influence of the shear geometry. We found significant differences for simple shear, where the sample is effectively under tension and shear accompanied with a compression.

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