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Some open questions in the elasticity of nematic liquid crystals: insights from microscopic theory

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The elastic behaviour of nematic liquid crystals is commonly interpreted on the basis of the Oseen-Frank free energy [1,2], in which the cost for distortions from the uniform alignment is decomposed into contributions corresponding to three modes – splay, twist, and bend - built from the first-order derivatives of the position dependent director. Typical low molecular mass thermotropic systems exhibit comparable elastic properties, weakly dependent on their chemical structure, which is in agreement with the prediction of classical microscopic theories [3]. Yet, the same does not apply to polymeric liquid crystals, whose elastic properties are still incompletely understood [4]. Recently, various examples of unusual elasticity have been highlighted: these include spontaneous twisting of the director in achiral chromonic liquid crystals, as well as an exceptionally low cost for bend or splay deformations in mesogens with unconventional shapes, which has been related to the formation of novel nematic phases [5]. In this talk we will discuss how, introducing new elements in the macroscopic theory [6], we can explain the variety of experimental behaviours.

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[2] F.C. Frank, *Discuss. Faraday Soc.* 25, 19 (1958).

[3] G. Vertogen and W. H. de Jeu, *Thermotropic Liquid Crystals, Fundamentals* (Springer, Berlin, 1988).

[4] K. Binder, S. Egorov, A. Milchev and A. Nikoubashman, *J. Phys. Mater.* 3, 032008 (2020).

[5] J. V. Selinger, *Annu. Rev. Condens. Matter Phys.* 49, 71 (2022).

[6] D. Revignas and A. Ferrarini, *Phys. Rev. Lett.* 125, 267802 (2020); *Phys. Rev. Lett.* 130, 028102 (2023); *J. Chem. Phys.* 159, 034905 (2023).

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