Interactions between Colloid Particles and Defect Lines in a Nematic Phase

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Abstract

A new interaction has been evidenced to drive colloids in suspension in the nematic phase [1]. This force, of the order a few picoNewtons, is specific to liquid crystals. It arises essentially from the distortions that the colloids produce around them and that interfere with distortions arising from other objects. For instance, this object may be a disclination line of strength +1/2 or -1/2 [2]. It may also be an artificial object as, for instance, the cylindrical volume that is melt in the isotropic phase by a sharp laser beam [3]. Because of the anchoring conditions of the director onto the interface between the isotropic and nematic phases, this melt cylinder produces a distortion of strength +1.

Both anchoring conditions on the colloid particles, homeotropic and planar, have been studied. In all cases, the experimental results are consistent with an electrostatic analogue. In particular, the interaction force exhibits power-law dependences as a function of the distance to the defect line, with an exponent being an integer that depends on the dipolar or quadrupolar symmetry of the nematic field around the particles, i.e. on the anchoring conditions chosen onto them.

In fact, the electrostatic analogy is not complete since the interaction does not obey the same symmetry law as in electrostatics. In some manner, the nematic interaction generalizes the electrostatics problem. A direct evidence is provided by the trajectories that the particles describe before reaching the defect line. They are clearly not straight lines, but rather complex curves that nevertheless may be calculated.

Interestingly, the interaction does not vanish when a particle is trapped on the line. The process is iterative and goes on until a lot of beads are captured onto the line. Finally, it self-assembles a necklace at the microscopic scale.

References

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