Electronic Supplementary Material (ESI) for Soft Matter.
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Supplementary Information for

Effect of temperature and electric field on 2D nematic colloidal crystals stabilised by vortex-like topological defects

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We have studied the temperature dependence of center-to-center separation of 5.2 μm particles across the N-SmA phase transition in 8CB. Figure S1(a) Shows the temperature dependence of of equilibrium separation. In the N phase, the separation (D) increases and it shows a sudden jump at the transition point. Recently James *et al.* theoretically studied the effect elastic anisotropy on the interparticle separation of a colloidal dimers formed by joining two colinear parallel dipolar colloids [1]. It has been shown theoretically that the equillibrium separation is given by

$$\frac{D}{R_0} \simeq 2.439 + 0.0879\left(1 - \frac{K_{11}}{K_{33}}\right) \qquad (1)$$

where R_o is the radius of the particle and K_{11} and K_{33} are the splay and bend elastic constants. Very recently we have experimentally shown that this slope is about 0.07. [2]

In order to see how it varies in case of dimer made of nonsingular defects, we collected the temperature dependence of K_{11} and K_{33} for 8CB from Ref. [3] and interpolated for all temperatures of interest. Fig. S1 (b) shows the variation of D/R_0 as a function of elastic anisotropy $(1 - K_{11}/K_{33})$ with the best fit to Eq. (1). The experimentally measured slope of D/R_0 for this dimer is 0.05, which is somewhat lower than that is observed in the dipolar dimers. This difference could be due to the type of defects and distortions, namely the dipolar dimers are connected by singular defects whereas the bubblegum dimers are connected by nonsingular defect.

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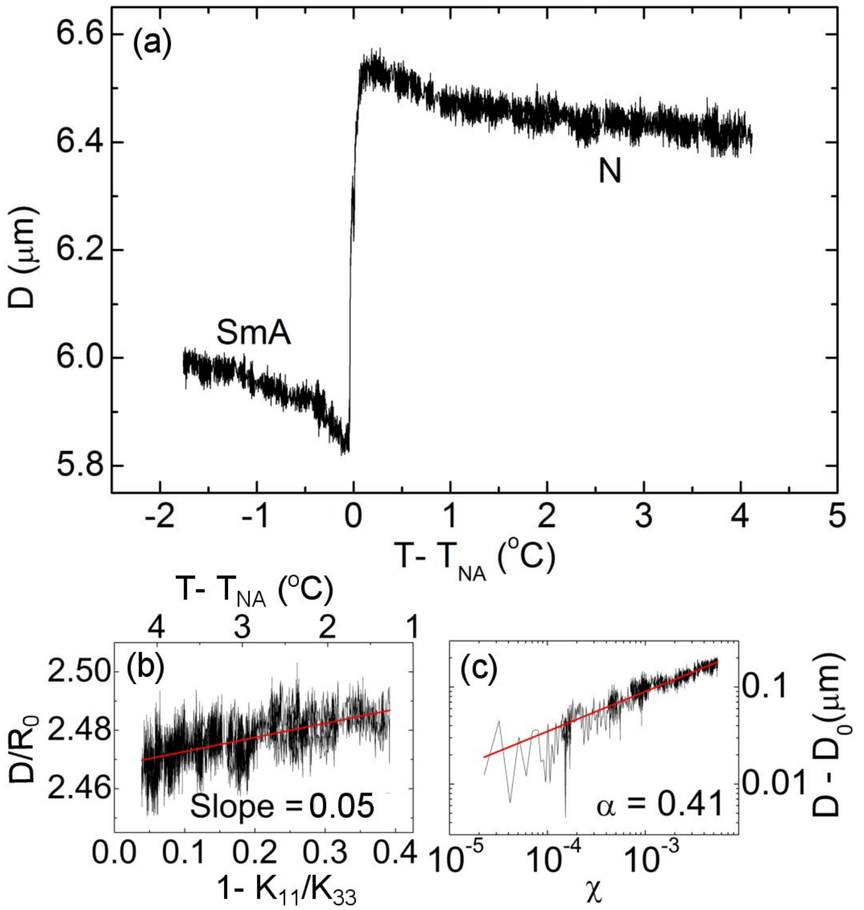

FIG. S1: (a) Variation of the center to center separation (D) of two homeotropic microspheres across the N-SmA transition in 8CB. The microsphere diameter is 5.2 μm, and the cell thickness is 8.5 μm. (b) Variation of D/R_0 above the N-SmA transition as a function of the elastic constant anisotropy ($1-K_{11}/K_{33}$). The red line is the best fit to Eq. (1) with slope 0.05. The scale on the top shows the temperature range that corresponds to the anisotropy range on the principal axis. (c) Variation of the separation with temperature below the transition (log scales). The red line shows the best fit to the power law $(D - D_0) \sim \chi^{\alpha}$ with $\alpha = 0.41$.

In the Sm*A* phase [Fig. S1 (a)], *D* is increasing with decreasing temperature from the *N*-Sm*A* transition point and tends to saturate at lower temperatures. Similar hebaviour was observed in case a pair of parallel dipoles [2]. This was attributed to the critical benaviour of the SmA layer compressibility modulus below N-SmA transition. It is known that in the SmA phase, the layer compression elastic modulus (*B*) varies as $B \sim \chi^{\alpha}$, where $\chi = (1 - T/T_{NA})$ is the reduced temperature, and the critical exponent α is between 0.39 and 0.42. To identify the role of the layer compression modulus, we fitted the temperature variation of separation to $(D - D_0) \sim \chi^{\alpha}$, where D_0 is the minimum value just below the transition. As shown in Fig. S1(c), the best fit gives critical exponent $\alpha = 0.41$.

The variation of equillibrium separation between the two colloids in TN cell of 8CB liquid crystals as a function of temperature is shown in Fig.S2. In N phase the separation is 6.5 ± 0.05 μm and we observed a slight increase in the separation as the temperature is decreased towards to the SmA phase followed by a sharp jump. In the SmA phase however, the temperature dependence of center to center distance is different than that is observed in case of PN cell (see Fig.S1). In particular, the critical behaviour is not observed in TN cell.

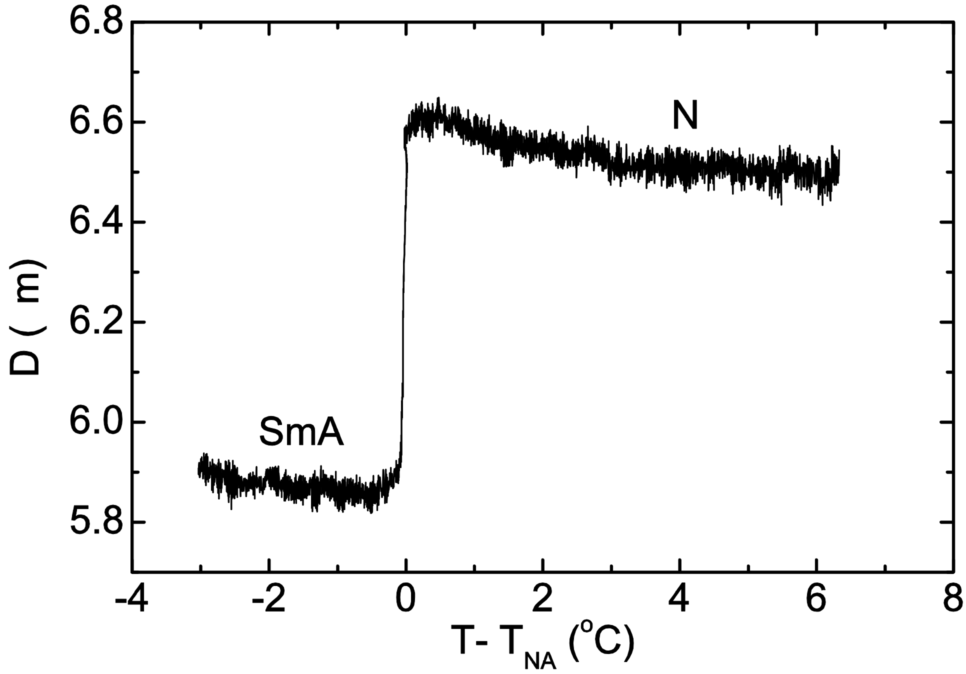

Fig.S2: Variation of centre to centre separation between two colloids with non-singular defect loop across the N-SmA phase transition in 8CB in TN cell. The particle size is 5.2 μm and cell thickness is 8.5 μm.

Description for Supplementary Videos:

Video-1 (File name: Video-1.wmv):
Transformation of vertex-like defect across N-SmA phase transition in 8CB in PN cell. Particle size is 5.2 μm and cell thickness 8.5 μm. The cooling rate is 0.2 ^{o}C/min. The time scale is compressed to show a short video clip.

Video-2 (File name: Video-2.wmv):
Transformation of vertex like defect across N-SmA phase transition in 8CB in TN cell. Particle size is 5.2 μm and cell thickness is 8.5 μm. The cooling rate is 0.2 ^{o}C/min. The time scale is compressed to show a short video clip.

Video-3 (File name: Video-3.wmv):
Temperature dependence of 2D colloidal crystal with vertex like defect across the N-SmA phase transition in 8CB in PN cell. Particle size is 5.2 μm and cell thickness 8.5 μm. The cooling rate is 0.5 ^{o}C/min. The time scale is compressed to show a short video clip.

Video-4 (File name: Video-4.wmv):
Temperature dependence of 2D colloidal crystal with vertex like defect across the N-SmA phase transition in 8CB in TN cell. Particle size is 5.2 μm and cell thickness is 8.5 μm. The cooling rate is 0.5 ^{o}C/min. The time scale is compressed to show a short video clip.

Video-5 (File name: Video-5.wmv):
Electric field dependence of 2D colloidal crystal with vertex like defect in PN cell. Particle size is 5.2 μm and cell thickness is 8.5 μm. The time scale is compressed to show a short video clip.

Video-6 (File name: Video-6.wmv):
Electric field dependence of 2D colloidal crystal with vertex like defect in TN cell. Particle size is 5.2 μm and cell thickness is 8.5 μm. The time scale is compressed to show a short video clip.

References

[1] R. James and J. Fukuda, Phys. Rev. E **88**, 10501R (2013).

[2] K. P. Zuhail, P. Sathyanarayana, D. Sec, S. Copar, M. Skarabot, I. Musevic and S. Dhara, Phys. Rev. E **91,** 030501R (2015).

[3] S. Morris, P. P. Muhoray and D. A. Balzarini, Mol. Cryst. Liq. Cryst., **139,** 263 (1986).