Abstract No. park665

X-ray Scattering Studies of Octylcyanobiphenyl in A Random Aerosil Network

S. Park (MIT), R. Leheny (MIT/Johns Hopkins), R. Birgeneau (MIT/U. of Toronto), J.-L. Gallani, C. Garland (MIT), and G. Iannacchione (WPI)

Beamline(s): X20C, X20A

Introduction: Dispersions of hydrogen bonded silica (aerosil) particles form a weak random network in liquid crystals. For polar liquid crystals like octylcyanobiphenyl (8CB), hydroxyl groups attached to the silica particle render anchoring forces. Thus, liquid crystalline transitions are expected to be affected by the random fields introduced by the random surfaces of the gel. The nematic (N) to smectic-A (SmA) transition, which has been studied extensively in pure liquid crystals [1], is known theoretically to be fragile under the introduction of a quenched random field [2], a feature confirmed experimentally through studies of 8CB in aerogel [3]. However, recent ac-calorimetry study has shown that aerosil networks do not affect the transition as severely as strongly-bonded aerogel networks [4]. We have studied the nature of N to SmA transition in 8CB in aerosil through X-ray diffraction, which directly reveals the smectic correlations [5].

Methods and Materials: 8CB+aerosil samples were prepared with several mass densities of aerosil by mixing the components with a volatile solvent and then thoroughly drying the solvent to leave a highly uniform gel within the liquid crystal. High resolution X-ray diffraction studies were conducted on these effectively powder samples in transmission geometry at temperatures both above and below the N-SmA transition temperature of the pure 8CB.

Results: The lineshapes obtained from X-ray scattering clearly show finite length correlations even for the lowest density (least perturbing) aerosil and down to the lowest measurement temperatures (more than 18 degrees below the N-SmA transition temperature of pure 8CB). This result confirms the classic Imry-Ma argument [6] that transitions breaking a continuous symmetry in 3D are destroyed by weak random fields. The x-ray lineshapes were fit to the sum of two terms: a Lorentzian with a fourth order correction in the transverse direction (thermal susceptibility term) and the square of this form with an independent amplitude (random field term). The success of these fits confirms the random field picture for 8CB in aerosil. The correlation lengths extracted from these fits range from 800 nm for 0.025 g/cc aerosil to 42 nm for 0.3 g/cc aerosil. These large correlation lengths at low aerosil density are consistent with the apparently singular heat capacity behavior observed with calorimetry [4].

Conclusions: This study has shown that 8CB with dispersed aerosil provides a model random field system for a transition that breaks a continuous symmetry. Consistent with theory, even the weak random field introduced by the lowest density aerosil network destroys the N-SmA transition.

Acknowledgments: This study was supported by the NSF under contract No. DMR-0071256 (MIT) and NSF-CAREER Award No. DMR-0092786 (WPI) and by the Natural Science and Engineering Research Council of Canada (Toronto). J.-L. G. acknowledges support from CNRS and NATO (grant 31C96FR).

References:

[1] C. W. Carland and G. Nounesis, "Critical Behavior at nematic-smectic-A phase transitions," Phys. Rev. E, **49**, 2964, 1994

[2] L. Radzihovsky and J. Toner, "Smectic liquid crystals in random environments," Phys. Rev. B, **60**, 206, 1999

[3] T. Bellini *et al*., Science, in press.

[4] G. S. Iannacchione, "Calorimetric and small angle X-ray scattering study of phase transitions in octylcyanobiphenyl-aerosil dispersions," Phys. Rev. E, **58**, 5966, 1998

[5] S. Park *et al*., Phys. Rev. Lett. submitted.

[6] Y. Imry and S.-K. Ma, "Random field instability of the ordered state of continuous symmetry," Phys. Rev. Lett., **35**, 1399, 1975