12. Optical Spectroscopy of Disordered Materials

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12.1 Studies of Micellar Liquid Crystals

In this program, we are studying the structure of ordered phases of surfactants. We use several different experimental techniques. To study long range orientational ordering of the surfactant aggregates, we use optical birefringence measurements. We have just put into operation at the Francis Bitter National Magnet Laboratory, in collaboration with Dr. Charles Rosenblatt, a mechanically stable apparatus for magnetooptical measurements up to 10 Tesla: this offers a signal to noise ratio 50 times better than our previous apparatus. The normal modes associated with the establishment of the micellar orientational order are studied by quasielastic light scattering, and high resolution x-ray scattering is used to study positional order of the micelles which occurs when the neat soap phase forms.

In previous studies[1,2] we established that the orientational order that occurs in micellar systems has much in common with that in thermotropic nematic liquid crystals. We also showed[3] that the nematic-isotropic transition in the two component system of cesium perfluoro octanoate (CsPFO) and water can be much closer to second order than in any other known liquid crystals. During the past year, we have been concentrating on the orientational order in the nematic phase to see how it vanishes near the nematic isotropic transition and how the normal modes are affected in the vicinity of the neat soap to nematic transition. The latter has a tricritical point and can be either first order or second order as the water content is changed.

Precise birefringence measurements have been carried out[4] throughout the nematic phase and show how the orientational order parameter varies near the weakly first order phase change. There is a coexistence region of about 150 mK, and the birefringence data are consistent with a Landau model for the transition. The order parameter jump at the transition is about 0.2. The linewidth of pretransitional nematic short range order fluctuations in the isotropic phase has also been measured by digital autocorrelation. The CsPFO/water system appears to be an ideal one to study behavior that occurs because the ordered phase lacks a preferred direction for the optic axis. The Goldstone modes (director modes in a nematic) are truly hydrodynamic with zero energy at long wavelengths;[5] thus transverse director fluctuations are important and reduce the effective order parameter as measured by the birefringence. A similar effect would occur in an isotropic Heisenberg ferromagnet, and theoretically causes an infinite zero field susceptibility in the ordered phase. We are currently studying the effects of these fluctuations in the micellar system. Short range lamellar order, which appears as a pretransitional form of the neat soap phase, causes a divergence of the nematic phase bend and twist elastic constants. We are studying this at the nematic to neat soap transition, particularly in the vicinity of the tricritical point.

12.2 Properties of Colloidal Crystals

In recent years there has been much interest in crystalline order formed by aqueous suspensions of polystyrene latex spheres. These have lattice parameters several hundred nm and have been studied as model systems for conventional crystals, for the preparation of ceramics, and to elucidate the properties of colloids. In previous, unpublished work we had studied "thermal diffuse" scattering of light by such crystals and determined the Lindemann ratio at the melting point to be 0.007, smaller than the typical value 0.2 in most conventional solids. We have recently followed up on that work, learning to prepare samples in water deionized by reverse osmosis as that promises to provide better control over sample properties. Our goal is to study the epitaxial growth of these crystals on carefully controlled surface relief structures prepared using submicron fabrication facilities.

References

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