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# Self-Consistent Treatment of the Layer Spacing in Smectic A Liquid-Crystals

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contrast, Au on CdS produces chemically-free S and Cd which diffuse away from the interface<sup>1</sup> into the metal. Analogous behavior occurs for Al vs. Au on  $\text{SiO}_2$  ( $X=1$ )<sup>1</sup>. For both CdS and  $\text{SiO}_2$ , Al forms strong metal-anion bonds and free cations while Au induces substrate dissociation and outdiffusion. The differences in metal-CdS bonding and related interface dipoles are shown to be characteristic of ionic semiconductors in general.

\* Work partially supported by NSF with SLAC and ERDA.

1. I. Lindau *et al.*, J. Vac. Sci. Technol. **15**, 1332(1978)
2. R.S. Bauer, R.Z. Bachrach, L.J. Brillson, and J.C. McMenamin, to be published.

#### SESSION AO: LIQUID CRYSTAL

Monday morning, 19 March 1979

Wisconsin Room at 9:00 A.M.

P. Cladis, presiding

**AO 1** Light Scattering Study above the Smectic-A to Smectic-C Transition in IOS5. J.T. HO and K.C. LIM, SUNY at Buffalo,\* and M.E. NEUBERT, Kent State U.—4-n-Pentylbenzenethio-4'-n-decyloxybenzoate is a liquid crystal with a smectic-A phase which extends over a range of 15°C and undergoes a transition to the smectic-C phase. We have used both the intensity and spectrum of Rayleigh scattering to study the critical angular fluctuations above the transition. Data in the non-hydrodynamic region are included in the analysis. The results yield a non-helium-like susceptibility critical exponent.

\* Supported by NSF Grant DMR-7807206.

**AO 2** Ultrasonic Shear Impedance Study of the Smectic A-Smectic B Phase Transition.\* S. BHATTACHARYA and S.V. LETCHER, Department of Physics, University of Rhode Island—Ultrasonic shear impedance measurements have been performed on BBOA with the polarization and propagation vector in the plane of the smectic layers. A frequency-dependent anomalous rise in the real part of the impedance was observed near the A-B transition. Possible implications of the results on the dynamics of the transition will be discussed.

\*Supported by NSF Grant #DMR 77-07813

**AO 3** Dynamics Near the Nematic-Smectic A and Nematic-Smectic C Phase Transitions in Liquid Crystals. KHURSHID A. HOSSAIN\* and J. SWIFT\*, University of Texas, and JING-HUEI CHEN\*\* and T.C. LUBENSKY\*\*, University of Pennsylvania.—The dynamics near the phase transitions in liquid crystals is investigated by a mode coupling method. There are five viscosities which enter the stress tensor in the nematic state of a liquid crystal. The contributions to these viscosities and the twist viscosity  $\gamma_1$ , from the order parameter fluctuations near the nematic-smectic A, nematic-smectic C transitions and the Lifshitz point are calculated. These quantities are expressed in terms of a viscosity,  $\gamma_3$ , which sets the time scale for the order parameter dynamics and the static order parameter correlation function. The parameter which describes the reversible coupling between the shear and the director is also calculated. These results are compared with those of Jähmig and Brochard<sup>1</sup> near the nematic to smectic A transition.

\*Supported by NSF under Grant No. DMR 76-11426.

\*\*Supported in part by NSF Grant No. DMR 76-21073, NSF MRL program Grant No. DMR 76-00678 and ONR Grant No. N00014-76-C-106.

<sup>1</sup>F. Jähmig and F. Brochard, J. Phys. (Paris) **35**, 301 (1974)

**AO 4** The Isotropic-Nematic Transition at Very High Magnetic Fields. P.H. Keyes, University of Mass at Boston and Francis Bitter National Magnet Lab\*, M.I.T.—Field induced birefringence and turbidity measurements are used to study the transition of the isotropic liquid to the nematic liquid crystal as a function of

both temperature and magnetic field. The critical exponents associated with this transition are found to be those expected for a tricritical point rather than those predicted by the deGennes mean field theory. It is also found that the mean field theory greatly underestimates the coupling of the order parameter to the field at high field values.

\*Supported by NSF

**AO 5** Re-entrance Phenomena in Mesomorphic PBLG Solutions\*, V.T. RAJAN and C.-W. WOO Northwestern U. ---PBLG molecules in solutions undergo individual helix-coil transitions. At sufficiently high concentrations, cooperative isotropic-nematic (cholesteric) transitions set in on account of intermolecular correlations. These transitions are coupled through the "induced rigidity" effect proposed by de Gennes and Pincus. We predict here using a two-parameter polymer model and a mean field theory, isotropic-nematic-isotropic re-entrance phenomena in PBLG dissolved in denatured solvents, and propose experimental conditions under which the phenomena may be observed.

\*This work was partially supported under the NSF-MRL program through the Materials Research Center of Northwestern University (grant DMR 76-80847) and also partially supported through grant No. DMR 76-18375.

**AO 6** Molecular Theory of Liquid Crystals. L. FEIJOO<sup>†</sup>, U. of Minnesota, V.T. RAJAN and C-W. WOO, Northwestern U.\*---- We have formulated the molecular theory of liquid crystals on the basis of a general probability distribution function  $P_N(1, \dots, N)$  and a corresponding free energy functional  $F_N\{P_N\}$ . It is seen that the Maier-Saupe mean field approximation results simply from constructing  $P_N(1, \dots, N)$  as a product of single particle functions. The "orientationally averaged pair correlation theory" developed by us in a previous paper, which treats spatial correlations as for a classical isotropic liquid and applies the mean field approximation only to orientations, results from the construction of a more sophisticated  $P_N(1, \dots, N)$  - one in which orientational and spatial correlations are decoupled. In this formulation, it is now clear as to how systematic improvements can be made on the approximation scheme, and how free energies can be evaluated in a way which is always consistent to the approximation scheme chosen.

Applications to PAA and MBBA give rise to volume changes and latent heats in reasonable agreement with experiment.

+CIC traveling Scholar at Northwestern U.

\*Work supported by NSF grant No. DMR 76-18375 and Mat. Res. Center of Northwestern Univ. grant No. DMR 76-80847.

**AO 7** dc Electric-Field-Induced Second-Harmonic Generation in a Nematic Liquid Crystal\*. S. K. Saha and G. K. Wong<sup>†</sup>, Northwestern University.—We report measurement of the macroscopic third order nonlinearity  $\Gamma$  of a nematic liquid crystal (5CB) with the technique of dc electric-field-induced optical second-harmonic generation. The effect of nematic ordering on  $\Gamma$  is observed. In principle, measurement of the components of  $\Gamma$  can be used to obtain the temperature dependence of the ordering parameters  $\langle P_2 \rangle$  and  $\langle P_4 \rangle$ . We also report experimental demonstration that the optical anisotropy of nematic liquid crystal can be used to achieve phase-matched second-harmonic generation.

<sup>†</sup>Alfred P. Sloan Foundation Fellow

\*Supported by the U.S. Army Research Office and in part by a Research Corporation Grant

**AO 8** Self-Consistent Treatment of the Layer Spacing in Smectic A Liquid Crystals. DAVID ALLENDER and MICHAEL KUZMA, Kent State Univ.—Following the analysis of x-ray data which indicate that the periodicity of the mass density wave in smectic A liquid crystals is significantly less than a molecular length, we present a mean field theory (modifying McMillan) in which the layer spacing,  $d_0$ , is treated self-consistently as  $d = d_0 \langle \cos \theta \rangle$ , where  $d_0$  is the molecular length and  $\theta$  is the angle between the long molecular axis and the

preferred direction normal to the layers. Since the nematic order is not complete,  $d$  will be less than  $d_0$ . Comparison will be made with experiment and an attempt will be made to empirically determine the parameters of the intermolecular potential for several compounds which exhibit the smectic A phase.

**AO 9 Laser-Ripplon Scattering from Lecithin Monolayers at the Water-Dodecane Interface.\*** NEIL BERGSTROM, JOE COSTELLO, and NABIL M. AMER, Applied Laser Spectroscopy Group, Lawrence Berkeley Laboratory, University of California, Berkeley. -- Monolayers of lecithin at the water-oil interface provide a suitable experimental system for investigating cooperative phenomena and phase transition in quasi-two-dimensions. In this configuration the individual molecules are in their "natural milieu": the polar heads are in the proximity of water and the aliphatic chains are in oil. Using light beating spectroscopy, we have measured the frequency and damping coefficient of the thermally excited ripplons (capillary surface waves) of a monolayer of lecithin (*L*- $\alpha$ -dipalmitoyl phosphatidyl choline) at the water-dodecane interface. Isotherms and isochores of this system will be presented and the static and hydrodynamic properties of the monolayer will be interpreted in the context of existing theories.

\* Research supported by the Department of Energy.

**AO 10 Anisotropic Surface Wave Propagation on Nematic and Smectic-A Liquid Crystals.\*** C. H. SOHL<sup>††</sup>, K. MIYANO<sup>\*</sup>, J. B. KETTERSON<sup>††</sup>, and G. WONG<sup>†</sup>, Argonne National Laboratory and <sup>†</sup>Northwestern University. -- We have employed low frequency ( $< 1$  kHz) surface waves at liquid gas interfaces to study a highly viscous isotropic fluid, and a liquid crystal (CBOOA) which undergoes a nematic to smectic-A phase transition. Numerical studies of the general dispersion relation for surface waves in both isotropic and anisotropic fluids have been made. Both cases can be parametrized in a dimensionless form without approximation, and it is shown that for certain ranges of the viscosity a two mode structure exists. We have experimentally verified this two mode structure on an isotropic fluid of large and known viscosity. Detailed measurements near the nematic to smectic-A transition in CBOOA for wave propagation both parallel (two mode case) and perpendicular (single mode case) to the magnetically aligned director were performed, and the temperature dependence of the viscosities  $\eta'_1$ ,  $\eta'_2$ , and  $\eta'_3$ , together with the surface tension  $\sigma$  determined. The divergence of  $\eta'_3$  is clearly seen. Preliminary studies of BBOA will also be reported.

\*Supported by the U. S. Department of Energy

**AO 11 Transformation of Defects Under Phase Transitions.\*** H.-R. TREBINI<sup>†</sup>, J.L. BIRMAN, City College, N.Y. -- Homotopy theory provides a very general classification scheme for topologically stable defects in partially ordered media like liquid crystals or the superfluid phases of He. Given phases 1 and 2 of isotropy subgroups  $H_1$  and  $H_2$ ,  $H_2 \subset H_1$ , the scheme has been used to study

- the transformation of point and line defects in the transition  $2 \rightarrow 1$  (by investigation of the homomorphism  $p_*: \pi_n(G/H_2) \rightarrow \pi_n(G/H_1)$ ,  $n = 1, 2$ );
- the breaking of point defects into line defects in the transition  $1 \rightarrow 2$ .

\*Work supported by the Deutsche Forschungsgemeinschaft, and NSF-DMR78-12339.

<sup>†</sup> On leave of absence from the Universität Regensburg, W. Germany.

**AO 12 Bubbles, Topology, and Liquid Crystals.\*** D. L. Stein, R. U. Pisarski, and P. W. Anderson<sup>\*\*</sup>, Physics Dept., Princeton U. -- Simple topological concepts are applied to the

study of defects in nematic liquid crystals; the topological properties of cholesteric and smectic liquid crystals appear to require deeper considerations, and the current state of the art will be discussed. The appearance of either surface or bulk singularities in the order parameter spaces of nematics and cholesterics given certain boundary conditions will also be reviewed, and comparison will be made with other condensed matter systems, especially anisotropic superfluids.

\*Supported by NSF Contract DMR 78-03015

\*\*Also at Bell Laboratories, Murray Hill, N.J. 07974

**AO 13 New Biaxial and Uniaxial Liquid Crystalline Phases in a Bilayer Lyotropic System.\*** N.A.P. VAZ<sup>\*\*</sup> and J.W. DOANE, Kent State U. -- Using optical and NMR techniques, we have observed several liquid crystalline phases within the lamellar phase of the potassium palmitate-water system. Optical conoscopic observations on homeotropically aligned samples show a sharp transition from a uniaxial to a biaxial pattern upon cooling. This transition is also readily observed with deuterium magnetic resonance on similarly aligned per deuterated samples, although the biaxial feature is not apparent. An order parameter based interpretation of the DMR spectra shows the high temperature phase to be of a smectic A,  $S_A$ , type. The uniaxial-biaxial phase transition, on the other hand, does not appear to be of the  $S_A$ - $S_C$  type observed in thermotropics. An additional liquid crystal phase transition is observed lower in temperature prior to the gel phase from both the optical and DMR methods.

\*Research supported in part by grants from the Institute for General Medical Sciences, GM-22599, and from the National Science Foundation, DMR76-21365.

\*\*On leave from Centro de Fisica de Matéria Condensada, Lisbon, Portugal.

**AO 14 Wall Induced Birefringence in a Nematic Liquid Crystal above the Nematic to Isotropic Phase Transition.** K. MIYANO, Argonne National Lab. -- It is well known that a wall bounding a liquid crystal causes an orienting action on the director, although the molecular origin of the anisotropic force is not well understood. The wall, therefore, acts as an external field. Hence, it is expected that this will cause a pretransitional birefringence above a nematic to isotropic phase transition similar to that induced by an applied magnetic field or shear flow. Thin nematic liquid crystal (5CB) samples were prepared in both planar and homeotropic orientation. The birefringence in these films was measured by a nulling ellipsometric technique with a resolution of  $5 \times 10^{-5}$  rad. A preliminary analysis of the divergent behavior using the Landau-de Gennes theory shows that the boundary condition of  $S=1$  on the wall is too strong. Detailed analysis will yield more insight of the physico-chemical nature of the orienting action of the wall.

\*Performed under the auspices of the U.S. Dept. of Energy.

**AO 15 Critical Behavior of the  $S_{mA}$ -C Transition in  $\bar{8}55$ .** M. KAPLAN, C.R. SAFINYA, J. ALS-NIELSEN, D. DAVIDOV, D.L. JOHNSON, J.D. LITSTER and R.J. BIRGENEAU, MIT<sup>a</sup>. -- We have used high resolution X-ray techniques to measure the tilt angle  $\phi$  and the planar spacing  $d_C$  near the second order  $S_{mC}$ - $S_{mA}$  transition in 4-n-pentylphenylthiol-4'-n-octyloxybenzoate ( $\bar{8}55$ ).  $\phi$  and  $\Delta d = d_A - d_C$  function as primary and secondary order parameters respectively of the C-A transition. We find that the ratio  $\phi/\cos^{-1}(d_C/d_A)$  is a constant =  $1.2 \pm .1$  throughout the C-phase thus supporting a simple molecular tilt model for the transition. For reduced temperatures  $5 \times 10^{-3} > 1 - T/T_C > 5 \times 10^{-5}$  ( $T_C = 55.01^\circ\text{C}$ ),  $\phi$  exhibits simple critical behavior with the exponent  $\beta = 0.47 \pm 0.04$ . This includes the mean field value  $\beta = 0.50$  within the errors. We present a simple Ginsburg criterion argument which indicates that the true critical region is unobservably small.

a. Work supported by the NSF-MRL and by the Joint Services Electronics Program.

**AO 16 X-Ray Studies of Two-Dimensional Liquid Crystal Films** D. E. MONCTON, R. PINDAK, BELL LABS - Freely