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ULTRASONIC ABSORPTION AND ORDER
OF THE SMECTIC-A-NEMATIC PHASE TRANSITION

R. BARTOLINO, F. SCUDIERI, D. SETTE and A. SLIVINSKI (*)
Istituto di Fisica, Facolta' di Ingegneria, Universita' di Roma, Roma, Italy,
and Gruppo Nazionale Struttura della Materia del Consiglio Nazionale delle Ricerche, Roma, Italy

Abstract. — Ultrasonic measurements in CBOOA near the smectic A-nematic transition show
the occurrence of critical absorption and therefore support the second order nature of the transition.

The order and the dynamical behaviour of smectic A-nematic transition (S\textsubscript{A}-N) in liquid crystals is at
the present a subject of theoretical and experimental investigation. McMillan’s theoretical model [1], as
well as some experimental results in CBOOA obtained by him [2] and by Doane \textit{et al.} [3], suggest, at least
in some systems, the second order nature of the transition. In such cases de Gennes proposes [4] an
analogy between a superconductor and a smectic A, obtaining interesting predictions on the temperature
behaviour of deformed samples and on pretransitional anomalies i. e. for the Frank elastic coefficients [5] in
nematic phase. In such an analysis a complex order parameter $\psi$ is introduced : its magnitude gives the
amplitude of the density modulation in the smectic phase, while the phase gives the layer position. Expe-
riments on the elastic coefficients by Durand \textit{et al.} [6], Meyer \textit{et al.} [7], Leger \textit{et al.} [8] and by Slivinski
\textit{et al.} [9] support de Gennes’ suggestion on the diver-
gence of the bend and twist elastic constants.

Brochard [10] has more recently presented an anal-
ysis in which a close connection with the dynamic
behaviour of liquid helium at the $\lambda$ point has been pointed out : in such a case the fluctuations of the
complex order parameter should be of great impor-
tance.

Interferometric measurements on the temperature
dependence of the bend elastic constant near the
S\textsubscript{A}-N transition have been performed by Cladis [11]
in CBOOA. Her conclusion is that the transition
could be a small first-order transition or a $\lambda$ transition.

Ultrasonic absorption measurements can be used to
give further information on the nature of the transition
and on the dynamics of the processes. In the present
communication we report some preliminary results
which seem to support second-order nature of the transition in CBOOA. A pulse interferometer has been
used at two frequencies (5 and 15 MHz). The smectic
material was CBOOA (N-p-cyano-benzilidene-p-n-octyloxyaniline) furnished by Eastman-Kodak, which
had a S\textsubscript{A}-N transition temperature of about 83 °C.
The experiments have been performed in the tempera-
ture range between 74 and 90 °C, in a bath whose
temperature has been kept constant within the accuracy
of ± 0,05 °C. The samples used were sealed in an argon
atmosphere and frequently changed in order
to avoid deterioration of the material.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{absorption_coefficient.png}
\caption{Absorption coefficient of ultrasound (in dB/cm)
      at a frequency of 5 MHz, vs. the difference $T - T_c$.}
\end{figure}

The absorption coefficient \textit{vs.} temperature in a
range of about ± 8 °C around the transition tempe-

tature ($T_c$) is given in figure 1 at 5 MHz and in
figure 2 at 15 MHz.
We wish here to call attention to the appearance of a maximum around $T_c$, which is more pronounced at lower frequency. Within the limits of accuracy of the present measurements the curve seems to be continuous and roughly symmetric around $T_c$. The whole process occurs in the range $T_c \pm 0.2$ °C. These results seem to indicate the presence of critical processes around $T_c$ and therefore to support the existence of a second-order transition. The critical process could be, in the Brochard picture, the interactions of sound waves with thermal fluctuations of the complex order parameter $\psi$, in analogy with the processes in helium at the $\lambda$ point [12, 13, 14, 15].

Research on sound absorption and velocity at various frequencies is at present being carried out, with better temperature definition in order to have further information both on the critical processes and on the dynamical behaviour of the two phases. We are also planning measurements on oriented monocrystalline samples.

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References