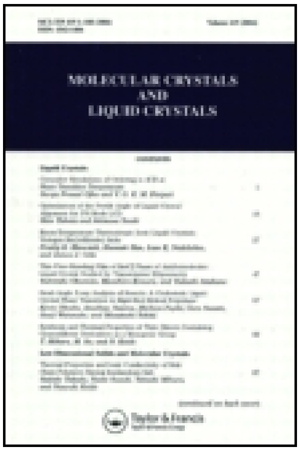

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Spontaneous Acoustic Emission (AE) at the Phase Transition in Smectic

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SPONTANEOUS ACOUSTIC EMISSION (AE) AT THE PHASE TRANSITION IN SMECTIC

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Abstract. AE resulted from fundamental processes of nucleation and growth during the spherulite crystallization of cholesteryl ester is discussed.

Crystallization with volume contraction effect is succeeded by sound radiation AE (1). Speculatively AE sources are the arising crystal nuclei (2). Statistical characteristics of AE time series is expected to have a consanguinity with morphology of overcritical nucleus, thermokinetics and dynamics of his evolution. However, due to method procedure errors the existing AE experimental data are insufficient to enable AE mechanism to be recognized unambiguously (3). Here we have investigated the AE induced directly by elementary processes of crystal nucleation and growth in cholesterylnonanoate with distinct thermal prehistory.

Experimental method of AE registration, minimization of subsidiary thermomechanical effects influence and improvement of signal/noise ratio were described previously (4). Kinetic and activation characteristics of the phase transition, parameters of interface dislocations and polarization were measured by independent methods (5, 6, 7) simultaneuosly with AE. To modify interface structure and charge state the thermal prehistory of liquid crystal was varied through realization of different sequences of phase transformations:

solid (351K) cholesteric1 (347K) smectic1 (317K) solid1 ;

solid (351K) cholesteric1 (362K) isotrop phase (355K) cholesteric2 (346K) smectic2
(321K) solid2 .

Smectics Sm1 and Sm2 have similar topologically pretransition textures of focal conics, but nonidentical density of interface structural defects and, accordingly, different morphological and electrokinetic properties of transition:

TABLE I. Interface morphology and electrokinetic parameters.

LC	b, mc	a, 1/m2	r, nm	S, erg/cm2	kA, 1/s3	G, mc/s	E, MV/m
Sm1	0.34	1.9	2.2	1.5	4.8	3.9	6.2
Sm2	0.44	4.4	2.6	2.0	6.2	6.4	9.9

In TABLE I **b**,**a** are Burgers vectors and density of dislocation walls ; r,**S** are critical radius of nucleus and interface energy : **kA** , **G** are a constant of transition rate and rate of spherulite growth ; **E** is a field of thermodielectric effect (7).

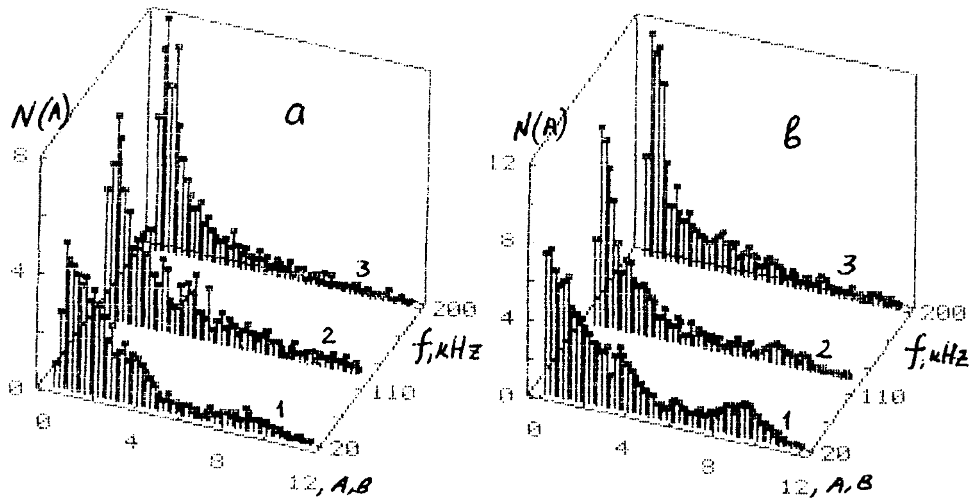

FIGURE 1 *AE amplitude distribution. a) - Sm1, b) - Sm2. Frequency of AE measuring f : 1-20, 2 110, 3-200 kHz.*

Amplitude distributions of AE pulses are given in fig.1. It will be seen that detected AE current is nonuniform and consists of two components with dissimilar amplitude, temporal and frequency parameters. The first, low amplitude constituent (LAE) has maximum of power spectra located in high frequency range. On the contrary, the second, high amplitude component (HAE) is shifted to low frequency region. Essentially, maximum location and magnitude of AE distributions are dependent on dislocation structure of interface (tabl. 1). Joint measurements of AE current and transition rates(fig. 2.a) show a strong evidence for LAE activity is limited by spherulite crystallization rate and depicted by Weibull distribution: NLAE ~ kAn tn - 1exp (-kAtn). n=3 is an Avrami constant of phase transition.

Comparison with quantity estimations of efficiency of mechanisms controlling AE sources (4) favours the LAE origin is due to dilatation effect of sporadic formation of overcritical nuclei and their subsequent development through secondary mechanism. HAEcomponent is generated by nonstationary glide of edge dislocation walls at the interface (4). This motion is induced by alteration of interface local curvature (6) and electrostriction deformation arising at fluctuations of the spherulite growth rate (7). By this sort of approach a HAE intensity is proportional to probability of spherulities collisions under the limited growth conditions and presented by modified Å-distribution: NHAE ~ (kA1/n t)8 exp [- (kA1/n t)3]. Taking into account an assumptions about LAE and HAE activities, we have evaluated distribution of time intervals between pulses in AE current. There is reasonable agreement speculative and experimental curves (fig. 2.b)

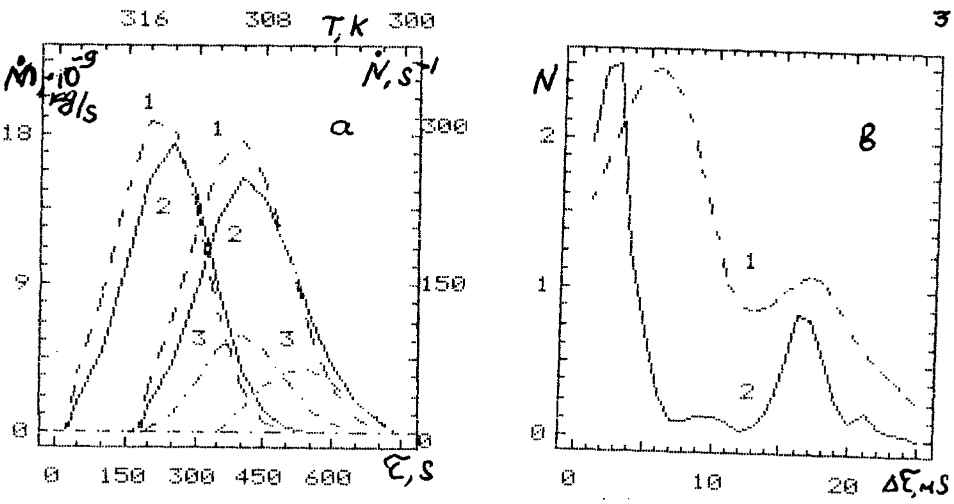

FIGURE 2. *AE during fractional crystallization.*
a) AE thermokinetics (f=20 kHz) · 1,1/ is a LAE count rate (Sm1 and Sm2 respectively); 2, 2/ is a crystallization rate ; 3,3/ is a HAE activity.
b) AE time interval distribution (Sm2, 20 kHz) : 1 is a calculated; 2 is an experimental curves.

Dependence of AE statistical properties on morphology of interface dislocations confirms the interrelation AE with transition thermokinetics and dynamics. To trim a randomizing factors action we have measured the AE during isothermal growth of single crystallization nucleus. Toward this end at the temperature T=343 K smectic (1,2) was deformed locally by means of conical microindenter. At the T=338 K subcritical nucleus of solid spherulite is formed in loading domain. During the isothermal keeping up to homogeneous nucleation beginning this single micronucleus was extended sizes about some millimetres. It is appeared the available growth of individual spherulite was followed by AE emergencies (Fig.3).

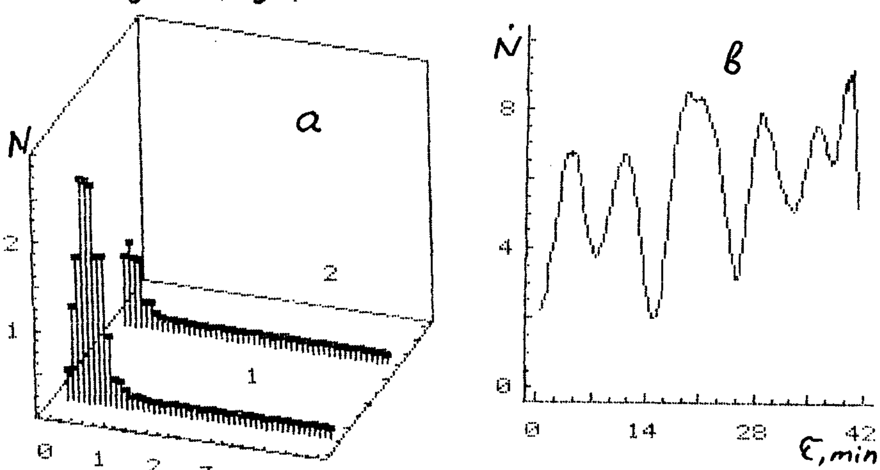

FIGURE 3. *AE during the single spherulite growth (20 kHz). a) amplitude distributions : 1 - Sm1; 2 - Sm2 ; b) AE count rate : Sm2 T=333 K*

Nevertheless, AE current of isolated nucleus has a number of features that are missing for the fractional crysta"ization (fig.1and 2). Amplitude distributions don't have HAE components and offer the obvious nonGaussian shape (fig.3,a). Simultaneously AE activity is discovered an evident quasiperiodic modulation (fig. 3,b). This infralow frequency garmonic constituent is responsible for both incomplete normalization of LAE after the bandpass filtering and nonexponential behaviour of the time interval distributions (fig 4.a). The later one was denoted a nonPoisson (correlated) nature of AE current resulted from cooperative modes making appearance during motion of detached spherulite interface. So, interface dynamics should be outlined by the determinate chaos approach.

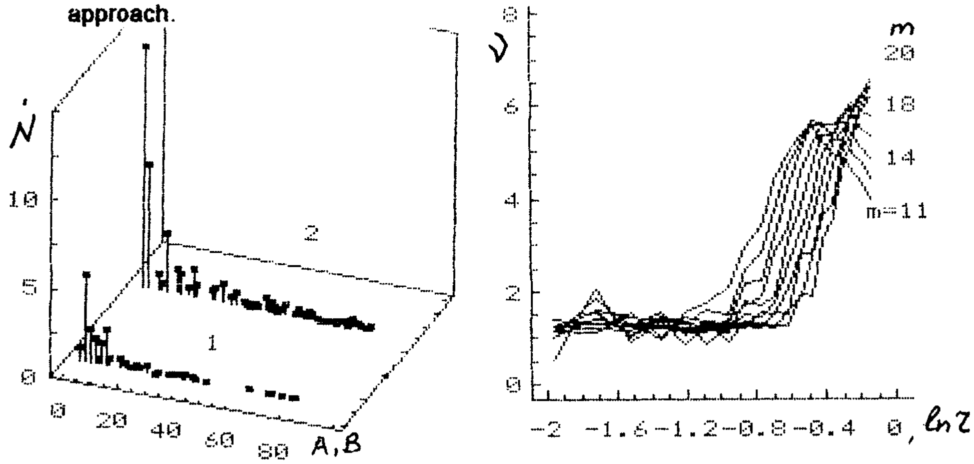

FIGURE 4. *Stochastic properties of AE current (single overcritical nucleus, 20kHz)*
a) time interval distributions :1-Sm1. 2-Sm2; b) correlation dimension of attractor Sm2.

Based on AE activity time series we have calculated correlation dimension (8) of chaotic attractor in a phase space of dynamic system fig.3, largest Lyapunov exponent ascertaining the divergence rate of trajectories winded on attractor and Heurst power estimating the persistent properties of AE current (9). Data are summarized in table II :

TABLE II. Multifractal dynamics of single spherulite interface

LC	correlation dimension, ν *small r*	*big r*	largest Lyapunov exponent, λ	Heurst power, H
Sm1	1,50;	5,52	0,349	0,793
Sm2	1,66;	6,02	0,556	0,582

The chief results are the following. First, spherulite growth is multifractal: at the same embedding dimensions (m) there are two areas of clustering on a fig.4,b ; slender value of ν is peculiar to the diffusion-limited aggregation (10)

Second, dependence of evaluated ν, λ, H - parameters on thermal prehistory of smectic occurs. Thus, AE method can be expected to give a new data regarding the thermokinetics and stochastic dynamics of real (imperfect) interface in liquid crystal.

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