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TEMPORAL EVOLUTION OF THE AMPLITUDE AND THE PHASE IN THE FORMATION PROCESS OF THE WILLIAMS DOMAIN

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In recent years, much attention has been paid to electro-hydrodynamic convection(EHC) in liquid crystals and, a lot of studies on EHC have been done, but not so many on the transient process of pattern formation. In this study, therefore, we have investigated the formation process of the one-dimensional periodic pattern called Williams domain from two different initial conditions. In the first condition, a system is set to be a uniform state in the absence of an applied electric field. In the second, the turbulent state under a strong electric field ($V = 30.0\ \mathrm{V_{rms}}$).

We used a cell with large aspect ratios ($\Gamma_x = \Gamma_y = 400$), which can be regarded as a two-dimensional system. Figure 1 shows the formation process of the Williams domain after applying an electric field. The formation process consists of the following two stages. In the first stage, some small domains of convective structure appear here and there, and then grow up, resulting in the appearance of dislocations. In the second stage, a pair of dislocations become close each other and then annihilate. Finally, the stable structure with no dislocation appears. To analyze this pattern formation process, we calculated the power spectrum images, $S(\mathbf{k})$, by the fast Fourier transformation. As shown in Fig. 2, an oval spot appears at first, and becomes sharp as time goes on. Figure 3 (a) shows the time dependence of the peak width of the power spectrum,

$$w_k = \sqrt{\frac{\sum_{\mathbf{k}} |\mathbf{k} - \bar{\mathbf{k}}|^2 S(\mathbf{k})}{\sum_{\mathbf{k}} S(\mathbf{k})}}, \qquad (\bar{\mathbf{k}} : \text{ averaged wave number})$$

in a plot of $\log w_k$ vs. $\log t$. The peak width decreases obeying a power law whose exponent is between -1/3 and -1/4 except the initial stage.

We simulated Ginzburg-Pitaevskii equation with Euler's method.

$$\frac{\partial W}{\partial t} = W - |W|^2 W + \kappa\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right) W$$

$$(|W_{\mathrm{ini}}| < 0.00001 \text{ random},\ \Delta t = 0.1,\ \Delta x = \Delta y = 1,\ \kappa = 0.1)$$

Figure 3 (b) shows the time dependence of the peak width of the power spectrum in the simulation. This peak width also decreases obeying a power law whose exponent is between -1/3 and -1/4. This result agrees with the experiment.

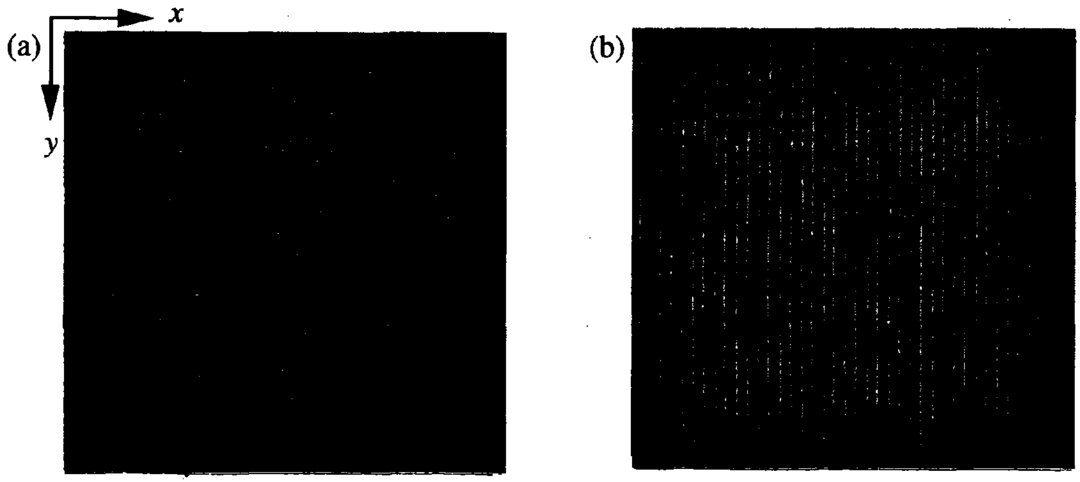

Fig. 1 The formation process of the Williams domain; (a) t = 16 sec, (b) t = 380 sec.

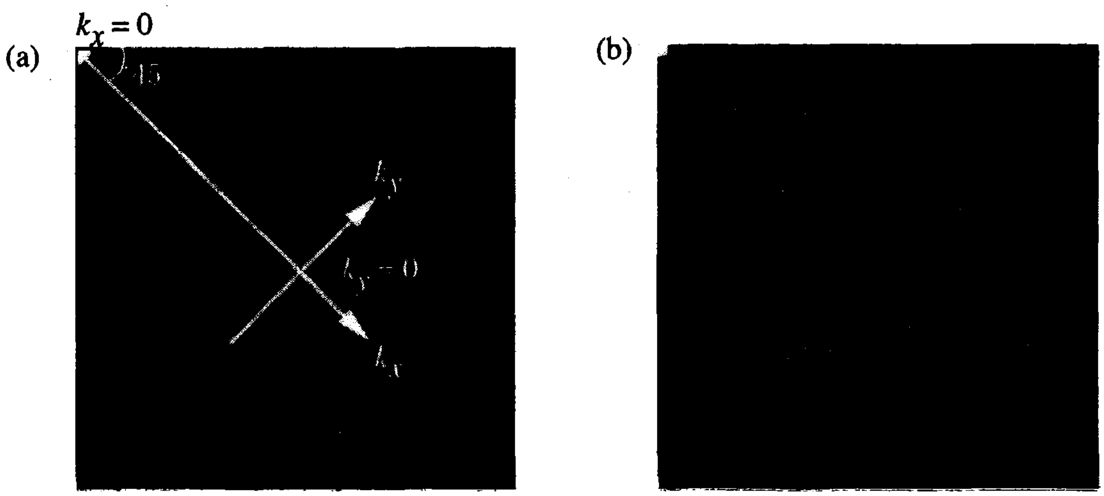

Fig. 2 The power spectra of the image intensity; (a) t = 16 sec, (b) t = 380 sec.

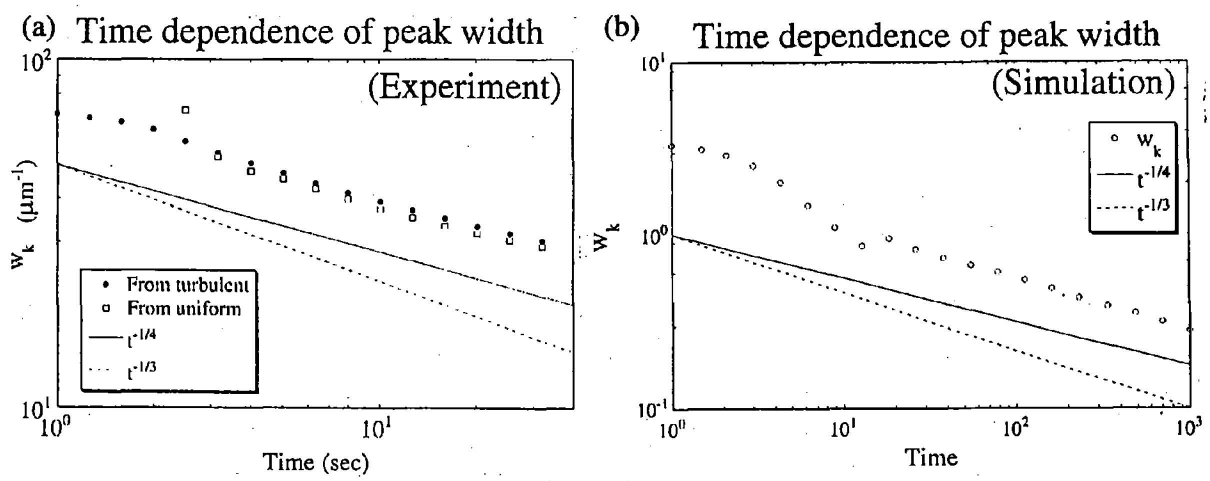

Fig. 3 The time dependence of the peak width of the power spectrum, w_k.
(a) experiment, (b) simulation.