Anisotropic electrohydrodynamic instability and decay of dielectric liquid into two-phase system of cylindrical vapor channels in a liquid

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Abstract *– A new physical phenomenon was discovered, namely an anisotropic instability of dielectric liquid in electric field and following decay into a two-phase system of vapor filaments in a liquid. The shift of spinodal and coexistence curves in an electric field was obtained theoretically and numerically. The hydrodynamic flow under the action of electrostrictive force was simulated both in uniform and in non-uniform field.*

1 Introduction

For most substances, a liquid (high-density) and a saturated vapor (low-density) phases can coexist in an interval of temperatures between the triple point and the critical point. The density of a liquid decreases with an increase of temperature, the density of a vapor increases. These densities become equal at the critical temperature. A homogeneous state below the coexistence curve with a density intermediate between equilibrium values for a liquid and a vapor can be either metastable (if $(\partial p/\partial\rho)_T > 0$) or unstable ($(\partial p/\partial\rho)_T < 0$). A metastable state can exist for relatively long time, and finally it decays into a two-phase system of pure liquid and vapor through the process of homogeneous or heterogeneous nucleation [1, 2]. Unstable states are thermodynamically prohibited, a homogeneous matter can not exist and decays very fast through a spinodal decomposition [3]. Experiments [4, 5] revealed that electric field influences the region of liquid stability. The shift of critical point in temperature was theoretically calculated earlier in [6]. Hence, the position of regions of different stability can be changed by external fields acting on a matter. The influence of an electric field is of particular theoretical and practical interest.

2 Anisotropic instability and decay in uniform electric field

The body force acting on charged dielectric liquid in electric field is given by the Helmholtz formula [6]

$$\mathbf{F} = q\mathbf{E} - \frac{E^2}{8\pi}\nabla\varepsilon + \frac{1}{8\pi}\nabla\left[E^2\rho\left(\frac{\partial\varepsilon}{\partial\rho}\right)_T\right]. \quad (1)$$

The second and third terms represent the action of electric field on polarization charges in nonuniform dielectric and the electrostriction force.

We focus our attention on ideal dielectrics with zero free charge; hence, first term in (1) falls out. If, moreover, the temperature is constant, we can rewrite the body force as

$$\mathbf{F} = \frac{\rho}{8\pi}\left[E^2\left(\frac{\partial^2\varepsilon}{\partial\rho^2}\right)_T\nabla\rho + \left(\frac{\partial\varepsilon}{\partial\rho}\right)_T\nabla E^2\right]. \quad (2)$$

For gases and liquids with weakly polarizable molecules, the permittivity depends linearly on fluid density

$$\varepsilon = 1 + 3\alpha\rho, \quad (3)$$

where $\alpha = 4\pi\beta/(3m)$, β is the molecular polarizability, m is the mass of a molecule.

For nonpolar liquids, the Clausius – Mosotti law [7] is valid

$$\varepsilon = 1 + 3\alpha\rho/(1-\alpha\rho). \quad (4)$$

For polar dielectrics, the analytical formula of Onsager, Kirkwood and Fröhlich is rather complicated, and it is more reliable to use the experimental values of ε, $(\partial\varepsilon/\partial\rho)_T$ and $(\partial^2\varepsilon/\partial\rho^2)_T$ that are usually positive.

Linear stability analysis of the Euler equations

$$\frac{\partial\rho}{\partial t} + \frac{\partial\rho u_i}{\partial x_i} = 0, \quad \frac{\partial\rho u_i}{\partial t} + \frac{\partial(p\delta_{ij} + \rho u_i u_j)}{\partial x_j} = F_i \quad (5)$$

for dielectric liquid under the action of electric field in the simplest isothermal case was carried out. Obviously, the isothermality of liquid should be imposed externally by forced heat inflow and removal.

A constant voltage was applied between two plane horizontal electrodes. In this case, only the vertical component of electric field E_z is non-zero. Let us consider a growth of small one-dimensional harmonic perturbations of density and velocity corresponding to the stratification of matter along the electric field

$$\rho = \rho_0 + A_0\exp(\gamma t)\exp(i2\pi x/\lambda),$$
$$u_x = C_0\exp(\gamma t)\exp(i2\pi x/\lambda) \quad (6)$$

and to the stratification across the electric field

$$\rho = \rho_0 + A_0\exp(\gamma t)\exp(i2\pi z/\lambda),$$
$$u_y = C_0\exp(\gamma t)\exp(i2\pi z/\lambda), \quad (7)$$

where λ is the wave length, A_0, C_0 are the initial

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amplitudes of perturbations, γ is the instability increment, ρ_0 is the mean density of a matter.

In the case of the perturbation (6), the magnitude of uniform electric field E_0 is constant. Hence, the body force (2) has the form

$$F_x = \frac{E_0^2 \rho}{8\pi}\left(\frac{\partial^2 \varepsilon}{\partial \rho^2}\right)_T \frac{\partial \rho}{\partial x} = K_x \frac{\partial \rho}{\partial x}, \qquad (8)$$

For the perturbation (7), the magnitude of electric displacement D_0 is constant in space and we have

$$F_z = \frac{D_0^2 \rho}{8\pi\varepsilon^2}\left(\left(\frac{\partial^2 \varepsilon}{\partial \rho^2}\right)_T - \frac{2}{\varepsilon}\left(\frac{\partial \varepsilon}{\partial \rho}\right)_T^2\right)\frac{\partial \rho}{\partial z} = K_z \frac{\partial \rho}{\partial z}. \quad (9)$$

In both cases, the instability increment is given by

$$\gamma = \frac{2\pi}{\lambda}\sqrt{-(\partial p/\partial \rho)_T + K}. \qquad (10)$$

From (8) and (9), the inequality $K_z < K_x$ always follows, hence, the equation of spinodal is given by

$$(\partial p/\partial \rho)_T = K_x. \qquad (11)$$

Similarly, the linear stability analysis of the one-dimensional Navier – Stokes equations [8]

$$\frac{\partial \rho}{\partial t} + \frac{\partial \rho u}{\partial x} = 0,$$
$$\frac{\partial \rho u}{\partial t} + \frac{\partial (p + \rho u^2)}{\partial x_j} = F + (4/3\mu + \xi)\frac{\partial^2 u}{\partial x^2} \qquad (12)$$

was carried out. Here, μ is the dynamic viscosity of a fluid, ξ is the coefficient of second viscosity.

The instability increment (10) increases as wave length of perturbations decreases and tends to infinity as wave length tends to zero. However, taking into account the fluid viscosity gives the following value of instability increment for small perturbations

$$\gamma = \frac{2\pi}{\lambda}\left(\sqrt{(\pi b/\lambda)^2 + K - (\partial p/\partial \rho)_T} - \pi b/\lambda\right), \quad (13)$$

where the quantity $b = (4/3\mu + \xi)/\rho_0$. For viscous fluid, the divergence of the instability increment for short waves does not take place, and its value is almost constant $\gamma_{\max} \approx (K - (\partial p/\partial \rho)_T)/b$ for wave lengths smaller than $\lambda_* \sim 2\pi b/\sqrt{K - (\partial p/\partial \rho)_T}$. Hence, the increase of instability increment is limited by viscous forces. The viscosity does not change the boundary of instability on $\tilde{T} - \tilde{\rho}$ diagram obtained from (11).

The expressions for instability increment for small perturbations along and across the electric field for a specific liquid are determined by the form of the density dependence of permittivity. The values for K are different for stratifications along and across the field. Hence, the instability increment depends on the orientation of initial perturbations.

For both the polar and nonpolar dielectric liquids $K_x > 0$, hence, the electric field increases the instability increment for perturbation of type (6). In all cases considered, we have $K_z < 0$, hence, the stability of a matter with respect to the stratification across the field is increased. Thus, for $K_x > (\partial p/\partial \rho)_T$, the anisotropic decay of homogeneous fluid into system of vapor filaments in a liquid parallel to the field occurs.

Considering growth of two-dimensional harmonic perturbations in the $x - y$ plane, we obtain the instability increments which are $\sqrt{2}$ times greater than (10) and (13) and a round cross-section of growing channels.

For the "gas" law (3), we have $K_x = 0$, hence, the instability is possible only in the region of forbidden states $(\partial p/\partial \rho)_T < 0$ same as in the case without electric field. However, even in this case, the instability is anisotropic. Indeed, the coefficient $K_z = -D_0^2(\varepsilon - 1)^2/(4\pi\varepsilon^3\rho) < 0$ is negative. Hence, the stability for stratification across the field is increased.

It is well known, that in an electric field, the critical point is shifted both in temperature and density [6]. The equation of the spinodal curve

$$(\partial p/\partial \rho)_T = \frac{E_0^2 \rho}{8\pi}\left(\frac{\partial^2 \varepsilon}{\partial \rho^2}\right)_T \qquad (14)$$

follows immediately from equations (8) and (11). This boundary of hydrodynamic stability exactly coincides with the boundary of thermodynamic stability of dielectric liquids obtained in [6].

However, the possibility of anisotropic instability and, consequently, the possible stratification of a matter were not considered in [6].

As an example, we considered a fluid with the van der Waals equation of state in reduced variables

$$\tilde{p} = 8\tilde{T}\tilde{\rho}/(3 - \tilde{\rho}) - 3\tilde{\rho}^2. \qquad (15)$$

For nonpolar liquids (4), we have

$$K_x = \frac{E_0^2}{36\pi}(\varepsilon - 1)^2 \frac{(\varepsilon + 2)}{\rho}. \qquad (16)$$

In this case, the formula of the spinodal curve can be written in an explicit form

$$\tilde{T} = \frac{\tilde{\rho}(3 - \tilde{\rho})^2}{4}\left(1 + \tilde{A}\frac{(\alpha\rho_{cr})^2}{(1 - \alpha\rho_{cr}\tilde{\rho})^3}\right). \qquad (17)$$

The second term in parentheses corresponds to the shift of the critical point in temperature. Here, $\tilde{A} = E_0^2/(8\pi p_{cr})$ is the dimensionless magnitude of

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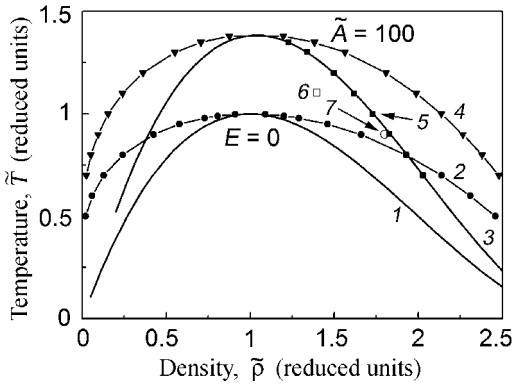

Fig. 1. Coexistence curves (2 and 4) and theoretical spinodals (17) (curves 1 and 3) for the van der Waals equation of state (15). Curves 1, 2 – without electric field, 3, 4 – in uniform electric field at $\tilde{A} = 100$. 5 – points of the spinodal obtained in hydrodynamic simulations by LBE method. Points 6 and 7 are the states initially above the critical point ($\tilde{\rho}_0 = 1.4$, $\tilde{T} = 1.1$) and in the region of stability of liquid phase ($\tilde{\rho}_0 = 1.8$, $\tilde{T} = 0.9$), respectively.

electric field squared. For parameters corresponding to argon $T_{cr} = 151$ K, $\rho_{cr} = 531$ kg/m^3, $p_{cr} = 4.86$ MPa, $\alpha\rho_{cr} = 0.057$, the spinodal curves were calculated and are shown in Fig. 1 for $E = 0$ (curve 1) and for $\tilde{A} = 100$ (curve 3). The shift of the critical point in density $\Delta\tilde{\rho}_{cr} \sim 2(\alpha\rho_{cr})\Delta\tilde{T}$ is very small due to the small value of parameter $\alpha\rho_{cr}$.

The critical density and the value of $\alpha\rho_{cr}$ for rare gases increase with the increase of atomic mass, hence, the shift of a spinodal in an electric field becomes more pronounced. Thus, for xenon, the shift of the critical point in reduced temperature is approximately twice as much as the shift for argon.

We performed the simulations of the evolution of homogeneous dielectric fluid that was initially at rest in uniform electric field (initial random density fluctuations in the nodes of the lattice were of order of $\Delta\rho/\rho_0 \sim 10^{-6}$. The dynamics of continuous media was simulated using the lattice Boltzmann equation (LBE) method [9, 10] modified to enable an arbitrary equation of state with possible phase transition [11, 12] and to take into account an action of electric forces (1) on a fluid [13]. Periodic boundary conditions in x direction were used. The neutral wetting of electrodes was assumed (the wetting angle was set equal to $\pi/2$). The distribution of electric field was obtained by solving the equations $\mathrm{div}(\varepsilon\nabla\varphi) = 0$ and $\mathbf{E} = -\nabla\varphi$ with boundary conditions $\varphi = 0$ and $\varphi = E_0 L_y$ at the lower and upper electrodes, respectively. The simulations were performed on a 150×150 lattice.

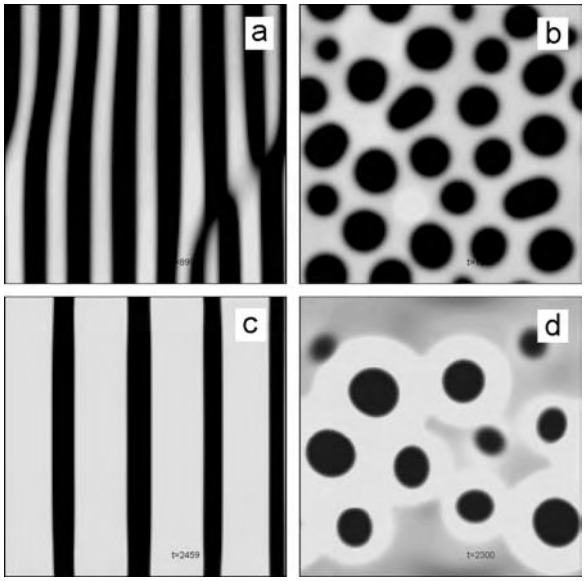

Fig. 2. Anisotropic stratification of fluid under action of uniform electric field. Stratification along the initially vertical field (a, c). Development of instability in the plane $x-y$ perpendicular to the field (b, d). The lower density is shown by dark color. In (a) and (b) $\tilde{\rho}_0 = 1.4$, $\tilde{T} = 1.1$ (state 6 in Fig. 1); in (c) and (d) $\tilde{\rho}_0 = 1.8$, $\tilde{T} = 0.9$ (state 7 in Fig. 1). $\tilde{A} = 100$.

For nonpolar dielectric (4), the coexistence (binodal) curves were obtained in computer simulations both without electric field (Fig. 1, curve 2) and in an initially vertical uniform electric field (curve 4). The high-density part of the spinodal curve (points 5) was also calculated. Both the spinodal and coexistence curves are shifted upward the more the larger is the value of an electric field squared.

The diagram obtained shows that the anisotropic decay of liquid along the field is possible for matter lying initially in metastable and even in stable states (states 6 and 7 in Fig. 1) not far from the initial coexistence curve in sufficiently high electric field. The same effect will be observed for polar dielectrics.

Predicted stratification along a uniform electric field was indeed observed in computer simulations for matter that was initially both in a state above the critical point (Fig. 2,*a*,*b*) and in a stable liquid state (Fig. 2,*c*,*d*). Simulations cover both the linear and nonlinear stages of instability. Instability arose in form of channels of approximately circular cross-section that generated compression waves during expansion (Fig. 2,*d*). This is a cooperative effect in the theory of nucleation [2]. The phase separation proceeded until the densities of phases reached the equilibrium values corresponding to the states on coexisting curve in presence of an electric field. In Fig. 2,*a*, branching and reconnection of vapor channels can be seen. This phenomenon is of stochastic nature, hence, it was observed not every run for the size of computation area used. A frame that demonstrates this phenomenon was specially

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chosen. For larger regions of uniform electric field, such reconnections will be more frequent.

The main drawback of all previous works on the behavior of dielectric liquids in high electric fields ([14, 15] and others) is that only the possibility of generation of spherical or ellipsoidal vapor bubbles was considered. The possibility of anisotropic instabilities already at the initial stage after voltage applied was not considered at all. Moreover, in the work [14], only the case of dielectric liquids with the linear density dependence of permittivity (3) was considered for which anisotropic instability is impossible for initially stable and metastable states as mentioned above. Hence, in [14], another mechanism of streamer growth was proposed that assumed the fast propagation of Griffith crack (similar to brittle material) in a liquid containing population of initial sub-microscopic spherical holes (bubbles). The mechanism considered in [14] is very interesting but fundamentally different from the mechanism of anisotropic instability proposed here.

In the process of breakdown of liquid dielectrics in strong electric fields that can locally reach the values of ~1–100 MV/cm (for different liquids), the proposed anisotropic instability is possibly the key mechanism of inception of streamer structures, their ultra-fast propagation in a form of thin filaments (the velocity can exceed 100 km/s [16]) oriented on average along the local electric field (Fig. 2,*a*,*c*), and also of their branching during propagation. Since the electric strength of low-density fluid (vapor) is lower, electric breakdown can occur in some of vapor channels produced by the anisotropic instability. When a filament becomes conductive, electric field in neighbor non-conductive channels decreases, and these channels disappear if their states leave the region below the coexistence curve. Electric field ahead of the conductive filament is on the contrary enhanced. Hence, the instability conditions are fulfilled in a new region of dielectrics. This process can propagate very fast step by step in the space between electrodes.

Experimental observation of the proposed electrohydrodynamic instability of dielectric liquids would be complicated because the electric breakdown of a low-density phase in strong electric field can occur simultaneously with the development of instability. The easiest way to separate these effects is, possibly, to investigate the initial states with temperature slightly higher than the critical one. In this case, relatively low electric fields are sufficient for the anisotropic instability, hence, a process of breakdown could be avoided.

Related process was investigated in [17], namely a partial separation of binary mixture in a non-uniform electric field. The moving force of this separation is a minimization of electrostatic energy, hence, a component with higher ε is pulled into a region of stronger electric field (in itself, a well-known effect). However, possible anisotropic decay was not considered. Our theory can be extended to the case of binary mixtures, and an anisotropic demixing is possible even in a uniform field if $(\partial^2\varepsilon/\partial\phi^2)_T \neq 0$ (ϕ is the concentration of one of the components). The consideration of binary mixtures is however more complicated and can be a subject of a future paper.

3 Electrostriction in non-uniform electric field

We consider electrostriction in initially homogeneous liquid between two concentric cylindrical or spherical electrodes (radius of the inner electrode R, radius of the outer one R_2). After application of a voltage, a region of higher density arises near the inner electrode behind a compression wave, and a region of rarefaction is produced near the outer electrode [18]. In the case of the constant electric displacement D_0 on the inner electrode, the radial dependence of electric induction εE is given by

Cylindrical electrodes	$\varepsilon E = D_0 R / r,$	(18.a)
Spherical electrodes	$\varepsilon E = D_0 R^2 / r^2.$	(18.b)

Flow of a liquid can be calculated by the perturbation method

$$\rho = \rho_0 + \Delta\rho, \tag{19}$$

$$u = u_0 + \Delta u. \tag{20}$$

There is no influence of electrodes upon the flow of a liquid in the region $R + c_0 t < r < R_2 - c_0 t$. Here, c_0 is the speed of sound. Hence, in the first approximation, the density of liquid is constant $\rho \approx \rho_0$, and the velocity is $u = u_0 = 0$.

Since the permittivity is constant for constant density, we obtain from (2) the volume force

$$F = \frac{\rho_0 (\partial\varepsilon/\partial\rho)_T}{8\pi} \nabla E^2. \tag{21}$$

For cylindrical and spherical electrodes, we have

Cylindrical electrodes	$F = -\frac{\rho_0 (\partial\varepsilon/\partial\rho)_T}{4\pi} \frac{D_0^2 R^2}{\varepsilon^2 r^3},$	(22.a)
Spherical electrodes	$F = -\frac{\rho_0 (\partial\varepsilon/\partial\rho)_T}{2\pi} \frac{D_0^2 R^4}{\varepsilon^2 r^5}.$	(22.b)

One-dimensional momentum equation (5) for a non-viscous liquid can be written as

$$\rho\left(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial r}\right) + \frac{\partial p}{\partial r} = F. \tag{23}$$

In the first approximation, the density is constant, hence, the pressure does not depend on coordinate, and the pressure gradient is equal to zero. In the second approximation ($\rho \approx \rho_0$, $u \approx \Delta u$), the momentum equation is given by $\rho_0 \partial(\Delta u)/\partial t = F$. Since the force does not depend explicitly on time,

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this equation can be integrated over time

$$\rho_0 \Delta u = Ft\,, \qquad (24)$$

which gives the velocity $u = u_0 + \Delta u$:

Cylindrical electrodes	$u = -\dfrac{(\partial\varepsilon/\partial\rho)_T}{4\pi}\dfrac{D_0^2 R^2}{\varepsilon^2 r^3}t\,,$ (25.a)
Spherical electrodes	$u = -\dfrac{(\partial\varepsilon/\partial\rho)_T}{2\pi}\dfrac{D_0^2 R^4}{\varepsilon^2 r^5}t\,.$ (25.b)

One can calculate the change of density $\Delta\rho$ using one-dimensional continuity equation

$$\frac{\partial\rho}{\partial t} + \frac{\partial\rho u}{\partial r} + \frac{(D-1)\rho u}{r} = 0\,, \qquad (26)$$

where D is the dimension of space. $D = 1, 2, 3$ corresponds to plane, cylindrical and spherical case, respectively. Using (19), (20) and (24), one obtains

$$\frac{\partial(\Delta\rho)}{\partial t} = -\left(\frac{\partial F}{\partial r} + \frac{(D-1)F}{r}\right)t\,. \qquad (27)$$

Integrating once more over time and substituting a formula for the force (22), we obtain the expression for the density

Cylindrical electrodes, flow in slot-like domain	$\dfrac{\rho}{\rho_0} = 1 - \dfrac{3D_0^2 R^2}{8\pi\varepsilon^2 r^4}\left(\dfrac{\partial\varepsilon}{\partial\rho}\right)_T t^2\,,$ (28.a)
Cylindrical electrodes and flow	$\dfrac{\rho}{\rho_0} = 1 - \dfrac{D_0^2 R^2}{4\pi\varepsilon^2 r^4}\left(\dfrac{\partial\varepsilon}{\partial\rho}\right)_T t^2\,,$ (28.b)
Spherical electrodes and flow	$\dfrac{\rho}{\rho_0} = 1 - \dfrac{3D_0^2 R^4}{4\pi\varepsilon^2 r^6}\left(\dfrac{\partial\varepsilon}{\partial\rho}\right)_T t^2\,.$ (28.c)

The approximate solution obtained is valid for small time while $\Delta\rho/\rho_0 << 1$, i.e.

$$\frac{Ft^2}{\rho_0 r} = \frac{ut}{r} << 1\,. \qquad (29)$$

Fig. 3 shows the flow corresponding to (28.a) in electric field between coaxial cylindrical electrodes computed by the one-dimensional LBE method. Dielectric parameters of the liquid were those of argon (see section 2), the magnitude of electric field at the inner electrode corresponded to $\widetilde{A} = 208.1$. Boundary conditions at $r = 2R$ were those of the continuity of a flow (fluid density and velocity).

At the initial stage when the density outside the domain of influence of electrodes is close to the initial one, computation and theoretical (25.a) results are in good agreement. Width of the domain of influence of the inner electrode can be estimated as $R + \int_0^t (c_0 - u_{\min})\,dt$ which is substantially less than the value $r < R + c_0 t$ obtained in [18] using the acoustic approximation for electrostrictive waves (Fig. 3). At the later stage, a shock wave is formed which propagates against the flow of liquid.

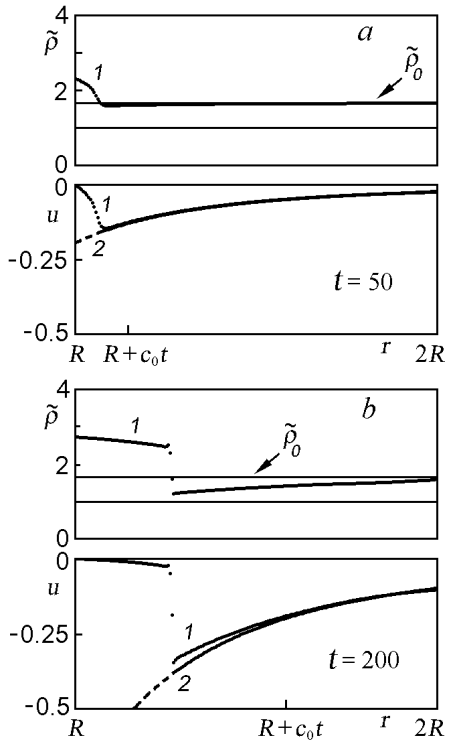

Fig. 3. Density and velocity distribution near the inner electrode $R < r < 2R$. Curves *1* are calculations by the LBE method $h = R/200$, curves *2* are theoretical ones (25.a). $t = 50$ (*a*), 200 (*b*). $\widetilde{T} = 0.9$, $\widetilde{\rho}_0 = 1.66$.

In Fig. 4, the results of simulation of electrostriction flow between cylindrical electrodes are shown. One can see a compression wave propagating radially. The magnitude of initial electric field at the inner electrode corresponded to $\widetilde{A} = 100$.

Besides this flow, the conditions for anisotropic instability described above can be fulfilled in non-perturbed region. Density of a fluid corresponding to a local spinodal (in presence of an electric field) ρ_{sp} depends on a radius r because the electric field decreases with increasing r (18). As the density decreases in time according to (28), the outer boundary of a region of anisotropic instability ($\rho < \rho_{sp}(r)$) expands in r (Fig. 3,*b*). However, to compute analytically processes in a non-uniform field is a complex problem, hence, a simulation with the LBE method was performed. The flow near a surface of a cylindrical electrode was computed in a layer $R < r < 1.25R$. Boundary conditions at $r = 1.25R$ were the continuity of fluid density and velocity. The outer electrode was sufficiently far in order not to influence the flow.

The Laplace equation in cylindrical coordinates was solved

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\varepsilon\frac{\partial\varphi}{\partial r}\right) + \frac{\partial}{\partial x}\left(\varepsilon\frac{\partial\varphi}{\partial x}\right) = 0\,. \qquad (30)$$

The x coordinate was along the inner electrode. Electric potential at boundaries $r = R$ and $r = 1.25R$ corresponded to the initial value

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Fig. 4. Electrostriction flow between cylindrical electrodes (black). High-density phase is shown in white. Initial state of a liquid was $\widetilde{\rho}_0 = 1.8$. $\widetilde{T} = 0.9$, $t = 173$ (in units of Fig. 3). Grid size 600×600. $h = R/300$.

$\widetilde{A} = 125.5$ at $t = 0$, $r = R$. Boundary conditions in x direction were periodic.

Simulation results are shown in Fig. 5. The compression (electrostriction) wave propagates radially from the inner electrode. Ahead this wave, the density is lowered due to a non-uniform velocity field (Fig. 3), and the anisotropic instability develops there. In this case, the kinematic viscosity was lower by the factor of two than for the simulation shown in Fig 4.

4 Conclusions

In summary, we discovered a new physical phenomenon, an anisotropic instability of a dielectric liquid in a uniform electric field and a segregation into a system of vapor filaments in a liquid. These filaments are on average parallel to the field. The shift of spinodal and binodal curves in an electric field was obtained from the linear stability analysis and in the computer simulations of electrohydrodynamics for a van der Waals fluid. Theoretical prediction of the decay of dielectric liquid into system of filamentary vapor channels in a liquid was confirmed in computer simulations both in uniform and non-uniform field.

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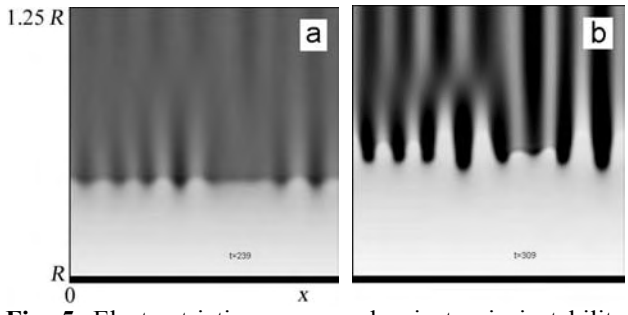

Fig. 5. Electrostriction wave and anisotropic instability near the surface of a cylindrical electrode. Low-density phase (vapor) is shown in black. Initial state of a liquid was $\widetilde{\rho}_0 = 1.8$. $\widetilde{T} = 0.9$. $t = 80$ (a), 103 (b) (in units of Fig. 3). Grid size 150×150. $h = R/600$

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