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CONVECTIVE INSTABILITY OF THE FLOW OF A BINARY MIXTURE UNDER CONDITIONS OF VIBRATION AND THERMAL DIFFUSION

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Stability of a plane–parallel flow of a nonuniformly heated binary mixture filling a vertical layer located in a field of gravity and in a high-frequency vibrational field is studied. The axis of vibrations is directed along the layer. The case of rigid and isothermal boundaries of the layer impermeable for the mixture is considered. The influence of thermal diffusion on the evolution of the admixture and the thresholds of flow stability is taken into account. The study is performed on the basis of equations for averaged fields. An asymptotic method with the use of the perturbation wavenumber as a small parameter is applied in the long-wave limit. For arbitrary values of the wavenumber, the limit of stability was determined by numerical integration. Charts of stability of gaseous and liquid binary mixtures are plotted.

Key words: *binary mixture, thermal diffusion, high-frequency vibrations, flow instability.*

Introduction. Thermal vibrational convection is usually understood as a set of phenomena associated with origination of regular flows in an inhomogeneous fluid under the action of vibrations. The mechanism of instability responsible for such motion is manifested even under conditions of microgravity [1]. Interaction of the thermal gravitational (Rayleigh's) and vibrational mechanisms of instability in a fluid with a homogeneous composition was considered in [2] for the case of a horizontal layer and in [3] for the case of longitudinal vibrations of an inclined layer. Regions of resonant parametric instability were found, and spatial and temporal properties of critical perturbations were examined. There are no resonant effects in the high-frequency limit where the period of vibrations is small as compared to the characteristic times of the system, and an averaging technique is used to derive the equations of convection [4]. The amplitude and frequency of vibrations are united into a single parameter: high-frequency vibrational Rayleigh number. Convective instability of a horizontal layer of a binary mixture under the action of transverse vibrations was first considered in [5] where the effect of thermal diffusion was ignored.

The problem of studying convection in binary mixtures and the mutual effect of fluid motion and thermal diffusion is urgent in various technological areas, for instance, in separating isotopes or separating fractions in petrochemical industry. The theory of convection of binary mixtures employs the Boussinesq approximation with allowance for dissipative processes of diffusion and thermal diffusion [6]. Instability of the binary mixture filling a plane horizontal channel bounded by rigid impermeable walls and possessing thermal diffusion in the field of longitudinal vibrations was considered in [7, 8].

In the present work, we study the vibrational convective instability of an upward–downward flow of an incompressible binary mixture with thermal diffusion in a vertical layer in the presence of longitudinal high-frequency harmonic vibrations.

Formulation of the Problem. We consider a binary mixture of nonreacting components, which fills the space between vertical solid plane–parallel planes $x = \pm h$ (vertical layer). The temperatures of the boundaries are

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constant: $T(\pm h) = \mp\Theta$. The z axis of the Cartesian coordinate system is directed upward. There is no external difference in concentrations, but a concentration gradient is established in an initially homogeneous mixture owing to the effect of thermal diffusion (Ludwig–Soret effect [9]).

We write the equation of state of the mixture in the form

$$\rho = \bar{\rho}(1 - \beta_T T - \beta_C C),$$

where $\bar{\rho}$ is the density of the mixture at certain mean values of temperature and concentration, T and C are the deviations of temperature and concentration from their mean values, and β_T and β_C are the coefficients of volume expansion of the fluid and the concentration limit of density. Assuming that C is the deviation of the concentration of the light component, we obtain $\beta_C > 0$.

The layer is located in a static gravity field $\boldsymbol{g} = g\boldsymbol{\gamma}$ ($\boldsymbol{\gamma}$ is a unit vector) and in a field of vertical (along the z axis) harmonic vibrations with an angular frequency Ω and an amplitude b. We consider the limiting case of high-frequency vibrations whose period $T_{\rm v}$ is much smaller than the hydrodynamic, thermal, and concentration (but not acoustic) characteristic times of the system:

$$T_{\rm v} \ll \min\,[h^2/\nu, h^2/\chi, h^2/D].$$

Here ν and χ are the kinematic viscosity and thermal diffusivity of the fluid, respectively, and D is the diffusivity.

The equations for the mean and fluctuating fields of velocity ($\boldsymbol{v}$ and $\boldsymbol{w}$), temperature T, and concentration C are obtained by a standard procedure of averaging [4] from the equations of convection in the Boussinesq approximation. We use the following scales: h for distance, h^2/ν for time, $g\beta_T\Theta h^2/\nu$ for velocity, Θ for temperature, $\beta_T\Theta/\beta_c$ for concentration, and $\rho g\beta_T\Theta h$ for pressure. After normalization, we write the averaged system of equations

$$\frac{\partial \boldsymbol{v}}{\partial t} + \mathrm{Gr}\,(\boldsymbol{v}\nabla)\boldsymbol{v} = -\nabla p + \Delta\boldsymbol{v} + (T + C)\boldsymbol{\gamma} + \frac{\mathrm{Ra_v}}{\mathrm{GrPr}}\,(\boldsymbol{w}\nabla)[(T + C)\boldsymbol{\gamma} - \boldsymbol{w}],$$

$$\frac{\partial T}{\partial t} + \mathrm{Gr}\,(\boldsymbol{v}\nabla T) = \frac{1}{\mathrm{Pr}}\,\Delta T, \qquad \mathrm{div}\,\boldsymbol{v} = 0, \tag{1}$$

$$]\,\mathrm{div}\,\boldsymbol{w} = 0, \qquad \mathrm{rot}\,\boldsymbol{w} = (\nabla T + \nabla C) \times \boldsymbol{\gamma}, \qquad \frac{\partial C}{\partial t} + \mathrm{Gr}\,(\boldsymbol{v}\nabla C) = \frac{1}{\mathrm{Sc}}\,(\Delta C - \varepsilon\Delta T),$$

where p is the pressure, $\mathrm{Gr} = g\beta_T\Theta h^3/\nu^2$ is the Grashof number, $\mathrm{Ra_v} = b^2\beta_T^2\Omega^2\Theta^2h^2/(2\nu\chi)$ is the vibrational Rayleigh number, $\mathrm{Pr} = \nu/\tilde{\chi}$ is the Prandtl number, $\mathrm{Sc} = \nu/D$ is the Schmidt number, and $\varepsilon = -\alpha\beta_C/\beta_T$ is the parameter of separation of the mixture (Soret parameter).

In system (1), the equation of motion of the mixture includes an additional vibrational force depending on the fluctuating component of velocity $\boldsymbol{w}$ and also on temperature and concentration inhomogeneities. The diffusion equation takes into account that concentration inhomogeneities can arise because of temperature inhomogeneities owing to thermal diffusion whose intensity is characterized by the Soret parameter ε. The sign of this parameter determines the direction of the flux of matter under thermal diffusion. For $\varepsilon > 0$, the direction of the flux of the light component coincides with the temperature gradient (normal effect). For $\varepsilon < 0$, the light component diffuses in the direction opposite to the temperature gradient (anomalous thermal diffusion).

The ideally heat-conducting and impermeable solid boundaries of the layer should obey the conditions of the absence of motion of the fluid and zero flux of matter and also the condition of a constant temperature:

$$x = \pm 1\colon \qquad \boldsymbol{v} = 0, \quad w_x = 0, \quad \frac{\partial C}{\partial z} - \varepsilon\,\frac{\partial T}{\partial z} = 0, \quad T = \mp 1. \tag{2}$$

The convective flow is assumed to be closed:

$$\int\limits_{-1}^{1} v_z(x)\,dx = 0. \tag{3}$$

Problem (1)–(3) has a steady solution, which describes a plane–parallel flow with a cubic profile of mean velocity, constant mean pressure, and linear distributions of fluctuating velocity and mean temperature and concentration:

$$\boldsymbol{v}_0 = (1 + \varepsilon)(x^3 - x)\boldsymbol{\gamma}/6, \quad p_0 = \mathrm{const}, \quad T_0 = -x, \quad C_0 = -\varepsilon x, \quad \boldsymbol{w}_0 = -(1 + \varepsilon)x\boldsymbol{\gamma}. \tag{4}$$

As is seen from Eq. (4), the amplitude of the mean and fluctuating components of velocity contains the factor $(1+\varepsilon)$, which leads to an increase in velocity for the case of normal thermal diffusion ($\varepsilon > 0$) and to a decrease in velocity for $\varepsilon < 0$.

Let us consider the stability of the basic state (4) to small perturbations:

$$\boldsymbol{v} = \boldsymbol{v}_0 + \tilde{\boldsymbol{v}}, \quad T = T_0 + \tilde{T}, \quad C = C_0 + \tilde{C}, \quad p = p_0 + \tilde{p}, \quad \boldsymbol{w} = \boldsymbol{w}_0 + \tilde{\boldsymbol{w}}.$$

After linearization of the problem of vibrational convection (1), (2), we obtain the following system of equations and the boundary conditions for small perturbations:

$$\frac{\partial \tilde{\boldsymbol{v}}}{\partial t} + \mathrm{Gr}\,(\boldsymbol{v}_0\nabla)\tilde{\boldsymbol{v}} + \mathrm{Gr}(\tilde{\boldsymbol{v}}\nabla)\boldsymbol{v}_0 = -\nabla\tilde{p} + \Delta\tilde{\boldsymbol{v}} + (\tilde{T}+\tilde{C})\boldsymbol{\gamma} + \frac{\mathrm{Ra_v}}{\mathrm{GrPr}}\,(\boldsymbol{w}_0\nabla)((\tilde{T}+\tilde{C})\boldsymbol{\gamma} - \tilde{\boldsymbol{w}}) + \frac{\mathrm{Ra_v}}{\mathrm{GrPr}}\,(\tilde{\boldsymbol{w}}\nabla)((T_0+C_0)\boldsymbol{\gamma} - \boldsymbol{w}_0),$$

$$\frac{\partial \tilde{T}}{\partial t} + \mathrm{Gr}\,(\boldsymbol{v_0}\nabla)\tilde{T} + \mathrm{Gr}\,(\tilde{\boldsymbol{v}}\nabla)T_0 = \frac{1}{\mathrm{Pr}}\,\Delta\tilde{T},$$

$$\frac{\partial \tilde{C}}{\partial t} + \mathrm{Gr}\,(\tilde{\boldsymbol{v}}\nabla)C_0 + \mathrm{Gr}\,(\boldsymbol{v}_0\nabla)\tilde{C} = \frac{1}{\mathrm{Sc}}\,(\Delta\tilde{C} - \varepsilon\Delta\tilde{T}), \tag{5}$$

$$\operatorname{div}\boldsymbol{v} = 0, \qquad \operatorname{div}\tilde{\boldsymbol{w}} = 0, \qquad \operatorname{rot}\tilde{\boldsymbol{w}} = (\nabla\tilde{T} + \nabla\tilde{C}) \times \boldsymbol{\gamma},$$

$$x = \pm 1: \qquad \tilde{\boldsymbol{v}} = 0, \quad \tilde{T} = 0, \quad \tilde{w}_x = 0, \quad \frac{\partial \tilde{C}}{\partial z} - \varepsilon\,\frac{\partial \tilde{T}}{\partial z} = 0.$$

First we consider the stability of the basic state (4) to plane perturbations: $\tilde{\boldsymbol{v}} = (v_x(x,z,t), 0, v_z(x,z,t))$, $\tilde{\boldsymbol{w}} = (w_x(x,z,t), 0, w_z(x,z,t))$, $\tilde{T}(x,z,t)$, $\tilde{C}(x,z,t)$, and $\tilde{p}(x,z,t)$. Instead of the fields of the mean and fluctuating components of velocity, we use the stream functions ψ and F:

$$\tilde{\boldsymbol{v}} = \Big(-\frac{\partial\psi}{\partial z}, 0, \frac{\partial\psi}{\partial x}\Big), \qquad \tilde{\boldsymbol{w}} = \Big(-\frac{\partial F}{\partial z}, 0, \frac{\partial F}{\partial x}\Big).$$

We seek for the solution in the form of normal modes:

$$\begin{pmatrix} \psi(x,z,t) \\ F(x,z,t) \\ \tilde{T}(x,z,t) \\ \tilde{C}(x,z,t) \end{pmatrix} = \begin{pmatrix} \varphi(x) \\ f(x) \\ \theta(x) \\ \xi(x) \end{pmatrix} \exp(-\lambda t + ikz). \tag{6}$$

Here k is the wavenumber, λ is the decrement, and $\varphi(x)$, $f(x)$, $\theta(x)$, and $\xi(x)$ are perturbation amplitudes. Substituting (6) into the system of equations for perturbations (5), we obtain a spectral–amplitude problem:

$$-\lambda\Delta\varphi = \Delta^2\varphi + \theta' + \xi' - ik\mathrm{Gr}\,(v_{z0}\Delta\varphi - v''_{z0}\varphi) + (1+\varepsilon)\,\frac{ik\,\mathrm{Ra_v}}{\mathrm{GrPr}}\,(f' - \theta - \xi),$$

$$-\lambda\theta = \frac{1}{\mathrm{Pr}}\,\Delta\theta - ik\mathrm{Gr}\,(v_{z0}\theta + \varphi), \qquad -\lambda\xi = \frac{1}{\mathrm{Sc}}\,\Delta\xi - \frac{\varepsilon}{\mathrm{Sc}}\,\Delta\theta - ik\mathrm{Gr}\,(v_{z0}\xi + \varepsilon\varphi),$$

$$\Delta f = \theta' + \xi', \tag{7}$$

$$x = \pm 1: \qquad \varphi = 0, \quad \varphi' = 0, \quad f = 0, \quad \theta = 0, \quad \xi' - \varepsilon\theta' = 0.$$

The prime in Eq. (7) indicates differentiation in terms of the transverse coordinate x, and a standard notation $\Delta = d^2/dx^2 - k^2$ is used.

The critical values of one of the parameters (Gr or $\mathrm{Ra_v}$) determining the boundary of stability depend on all other parameters of the system: $\mathrm{Ra_{v*}} = \mathrm{Ra_{v*}}(\mathrm{Gr}, \mathrm{Pr}, \mathrm{Sc}, \varepsilon, k)$ and $\mathrm{Gr}_* = \mathrm{Gr}_*(\mathrm{Ra_v}, \mathrm{Pr}, \mathrm{Sc}, \varepsilon, k)$.

Long-Wave Instability. The condition of impermeability for the flux of matter at the boundaries of the layer of the binary fluid leads to long-wave instability ($k = 0$). We write the solution of the amplitude problem (7) in the form of series in terms of the small parameter k:

$$\lambda = \sum_{n=0}^{\infty} \lambda_n k^n, \quad \varphi = \sum_{n=0}^{\infty} \varphi_n k^n, \quad f = \sum_{n=0}^{\infty} f_n k^n, \quad \theta = \sum_{n=0}^{\infty} \theta_n k^n, \quad \xi = \sum_{n=0}^{\infty} \xi_n k^n. \tag{8}$$

Substituting series (8) into the boundary-value problem (7), we obtain consecutive approximations for finding the decrements and amplitudes of perturbations. In the zero order in terms of k, all levels of the spectrum, except for one neutral level of the concentration type, correspond to decaying perturbations:

$$f_0 = \theta_0 = \varphi_0 = \lambda_0 = 0, \qquad \xi_0 = \text{const}. \tag{9}$$

In what follows, we use normalization ($\xi_0 = 1$). In the first order in terms of k, we have an inhomogeneous system

$$\varphi_1^{\mathrm{IV}} + \theta_1' + \xi_1' - (1+\varepsilon)\,\frac{i\,\mathrm{Ra_v}}{\mathrm{GrPr}} = 0,$$

$$\theta_1'' = 0, \qquad f_1'' = \xi_1' + \theta_1', \qquad \frac{1}{\mathrm{Sc}}\,(\xi_1'' - \varepsilon\theta_1'') - i\mathrm{Gr} v_{z0} = -\lambda_1.$$

The condition of its solvability is obtained by integrating the equation for the concentration across the layer from -1 to 1. With allowance for the boundary condition for concentration and oddity of the profile v_{z0}, we obtain $\lambda_1 = 0$.

The eigenfunctions of the first-order problem have the form

$$\varphi_1 = i(1+\varepsilon)\Big[-\frac{\mathrm{GrSc}}{576}\Big(\frac{x^8}{70} - \frac{2x^6}{15} + x^4 - \frac{58x^2}{35} + \frac{163}{210}\Big) + \frac{\mathrm{Ra_v}}{24\mathrm{GrPr}}\,(x^4 - 2x^2 + 1)\Big], \qquad \theta_1 = -x,$$

$$\xi_1 = i\mathrm{GrSc}\,(1+\varepsilon)\Big(\frac{x^5}{120} - \frac{x^3}{36} + \frac{x}{24}\Big), \qquad f_1 = \frac{i\mathrm{GrSc}\,(1+\varepsilon)}{48}\Big(\frac{x^6}{15} - \frac{x^4}{3} + x^2 - \frac{11}{15}\Big).$$

In the second order, we obtain the following system:

$$\varphi_2^{\mathrm{IV}} + \theta_2' + \xi_2' = i\mathrm{Gr}\,(v_{z0}\varphi_1'' - v_{z0}''\varphi_1) + (1+\varepsilon)\,\frac{i\,\mathrm{Ra_v}}{\mathrm{GrPr}}\,(f_1' - \theta_1 - \xi_1), \qquad f_2'' = \theta_2' + \xi_2',$$

$$\frac{1}{\mathrm{Pr}}\,\theta_2'' = ik\mathrm{Gr}\,(v_{z0}\theta_1 + \varphi_1), \qquad \frac{1}{\mathrm{Sc}}\,\xi_2'' - \frac{\varepsilon}{\mathrm{Sc}}\,\theta_2'' = \frac{1}{\mathrm{Sc}} - \lambda_2 + i\mathrm{Gr}\,(v_{z0}\xi_1 + \varepsilon\varphi_1). \tag{10}$$

The correction λ_2 determining the boundary of long-wave instability is found from the condition of solvability of system (10). Integrating the equation for concentration perturbations across the layer, we obtain

$$\lambda_2 = \frac{2}{\mathrm{Sc}} + \frac{4}{2835}\,\mathrm{Gr}^2\mathrm{Sc}\,(1+\varepsilon)(1+2\varepsilon) - \frac{2}{45}\,\frac{\mathrm{Ra_v}\,\varepsilon(\varepsilon+1)}{\mathrm{Pr}}.$$

For $\lambda_2 = 0$, we obtain a relation between the parameters of the problem, which corresponds to the boundary of long-wave instability:

$$2835\mathrm{Pr} + 2\mathrm{Gr}^2\mathrm{Sc}^2\mathrm{Pr}\,(1+\varepsilon)(1+2\varepsilon) - 63\,\mathrm{Ra_v}\,\varepsilon(1+\varepsilon)\mathrm{Sc} = 0. \tag{11}$$

This expression is a generalization of two previously examined limiting cases:

1) In the absence of vibrations ($\mathrm{Ra_v} = 0$ and $\mathrm{Gr} \neq 0$), Eq. (11) yields an expression for the critical Grashof number at the boundary of stability of the thermal concentration flow [10]

$$\mathrm{Gr}^2 = -2835/[2\mathrm{Sc}^2(1+\varepsilon)(1+2\varepsilon)] \geqslant 0,$$

which implies that long-wave instability exists only in the region of the anomalous Soret effect $-1 < \varepsilon < -1/2$;

2) In the absence of gravity ($\mathrm{Gr} = 0$ and $\mathrm{Ra_v} \neq 0$), the threshold of the long-wave mode of a thermal vibrational flow [7] is determined by the condition

$$\mathrm{Ra_v} = 45\mathrm{Pr}\,/[\varepsilon(1+\varepsilon)\mathrm{Sc}].$$

Only non-negative vibrational Rayleigh numbers $\mathrm{Ra_v}$ have a physical meaning; hence, the long-wave instability exists for all values of the parameter of separation of the mixture in the region of the normal Soret effect ($\varepsilon > 0$) and only for $\varepsilon < -1$ in the region of the anomalous Soret effect.

The dependences between the problem parameters, which refer to neutral long-wave perturbations, in the general case of the mutual influence of thermal vibrational and thermal gravitational mechanisms of instability ($\mathrm{Ra_v} \neq 0$ and $\mathrm{Gr} \neq 0$) are plotted in Figs. 1 and 2. With increasing vibrational Rayleigh number, the thresholds of long-wave instability of the flow also increase. The dependences $\mathrm{Ra_v}(\mathrm{Gr})$ for a fixed value of the Soret parameter are parabolas (see Fig. 2).

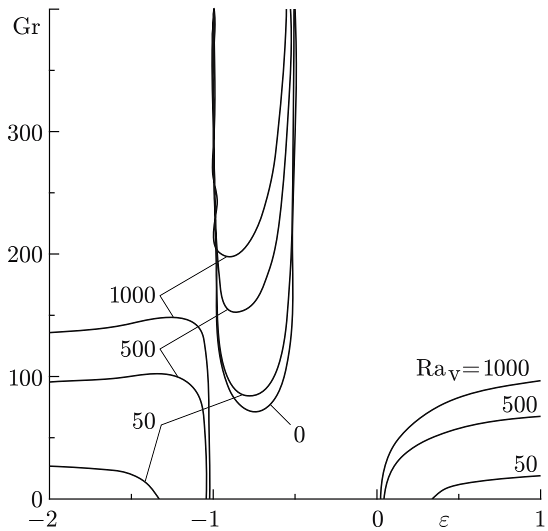

Fig. 1

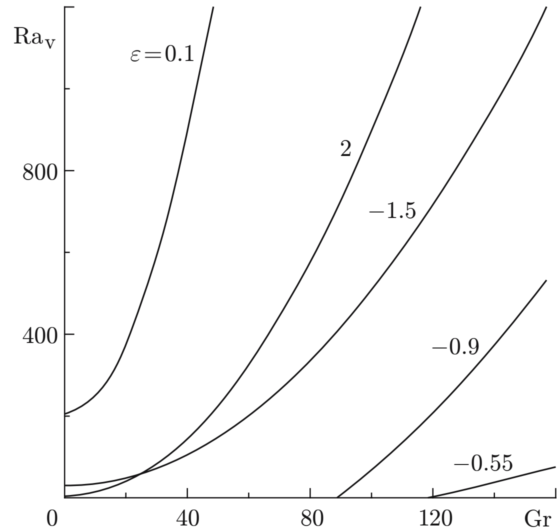

Fig. 2

Fig. 1. Threshold values of the Grashof number of long-wave instability versus the Soret parameter for different values of the vibrational Rayleigh number (gas mixture; Pr $= 0.75$ and Sc $= 1.5$).

Fig. 2. Threshold values of the vibrational Rayleigh number of long-wave instability versus the Grashof number for different values of the Soret parameter (gas mixture; Pr $= 0.75$ and Sc $= 1.5$).

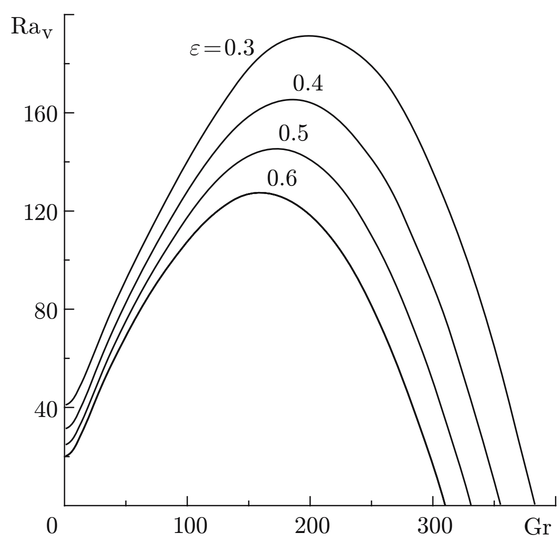

Fig. 3. Charts of stability for a gas mixture (Pr $= 0.75$ and Sc $= 1.5$) in the case of normal thermal diffusion.

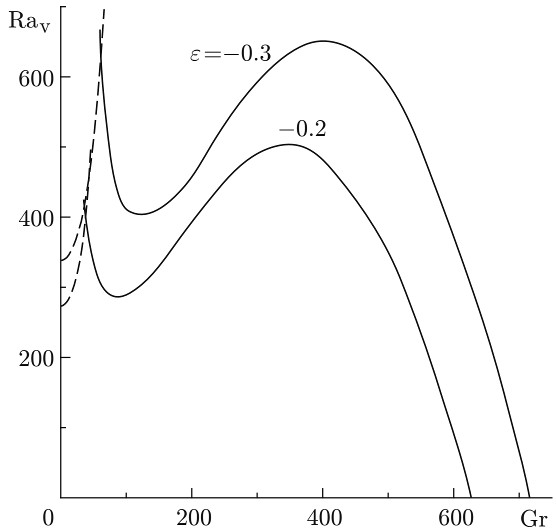

Fig. 4

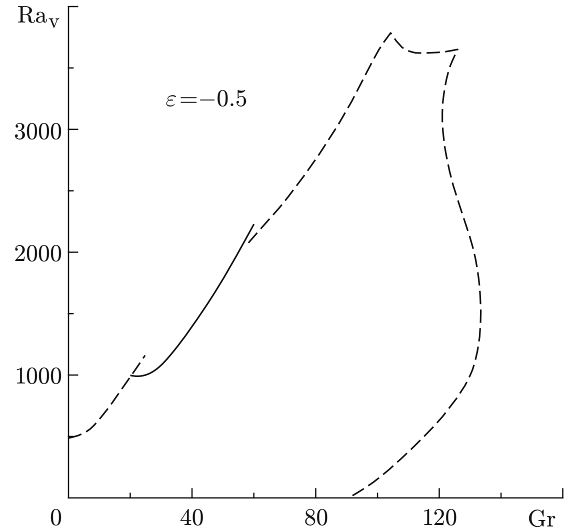

Fig. 5

Fig. 4. Charts of stability for a gas mixture (Pr = 0.75 and Sc = 1.5) in the case of anomalous thermal diffusion.

Fig. 5. Chart of stability for a liquid binary mixture (Pr = 6.7 and Sc = 676) in the case of anomalous thermal diffusion.

Numerical Results. The solutions of the spectral–amplitude problem (7) for perturbations with a finite wavenumber are sought with the use of differential sweep [11] and orthogonalization [10].

Let us first discuss the flow instability in a binary gas mixture (Pr = 0.75 and Sc = 1.5). Figure 3 shows the charts of instability for the case of a positive Soret effect ($\varepsilon > 0$), which characterize the interaction of the hydrodynamic and static vibrational mechanisms of flow instability. Hereinafter, the region of stability of the basic state is adjacent to the origin of the coordinate system. In microgravity (Gr = 0), the mean flow of the binary mixture is absent, but there exist high-frequency fluctuations of the mixture. Instability arises owing to the action of the thermal vibrational mode of instability on the background of quasi-equilibrium of the medium filling the layer. An increase in the Grashof number leads to an increase in the thresholds of convection with respect to this mode: the arising thermal gravitational flow prevents the formation of convective waves by smearing the arising structures. In the other limiting case (in the absence of vibrations, $\mathrm{Ra_v} = 0$), we obtain the problem of stability of a plane–parallel flow in a vertical layer. An increase in the vibrational parameter $\mathrm{Ra_v}$ decreases the threshold of stability of the convective flow. An increase in the Soret parameter, according to Eq. (4), intensifies the mean and fluctuating flows and, hence, reduces the region of stability of the basic state.

In the case of an anomalous effect of thermal diffusion, the charts of stability of the gas mixture are qualitatively different (Fig. 4). In microgravity (Gr = 0), the binary mixture is unstable to cellular vibrational perturbations (dashed curves). In this particular case, monotonic perturbations are less dangerous, as was demonstrated in [7]. An increase in the Grashof number initiates origination of a thermal gravitational flow: interaction of vibrational and hydrodynamic modes of instability increases the thresholds of vibrational convection; simultaneously, the boundary of the monotonic mode decreases. If the Grashof number exceeds a certain critical value $\mathrm{Gr}_*(\varepsilon)$, monotonic perturbations become the most dangerous ones. An increase in the absolute value of the Soret parameter expands the range of stability; the segment of the boundary corresponding to vibrational perturbations increases.

For a water–salt mixture (Pr = 6.7 and Sc = 676), the boundary of the stability region in the range of the anomalous Soret effect ($\varepsilon = -0.5$) consists of the region of neutral monotonic perturbations and various regions of vibrational modes in which the perturbations differ in their wavenumbers and frequencies (Fig. 5).

Studying the stability of the binary mixture flow to spatial perturbations ($v_y \neq 0$ and $w_y \neq 0$) with wavenumbers $k_z \neq 0$ and $k_y \neq 0$, we can obtain transformations similar to Squire's transformations [9]. The formulas for recalculating the critical values of Gr and $\mathrm{Ra_v}$ for three-dimensional perturbations in the problem of the flow of a binary mixture under the action of high-frequency vibrations are obtained if the parameters of plane pertubations $\overline{\mathrm{Gr}}$, $\overline{\mathrm{Ra}}_\mathrm{v}$, and $\bar{k}$ are known:

$$a = k_z \Big/ \sqrt{k_z^2 + k_y^2}, \qquad \mathrm{Gr} = \overline{\mathrm{Gr}}/a, \qquad \mathrm{Ra_v} = \overline{\mathrm{Ra}}_\mathrm{v}/a^2.$$

The parameter a characterizes the spatial orientation of the wave vector of perturbations. The analysis of stability of the mixture flow under the action of longitudinal vibrations shows that plane perturbations ($a = 0$) are more dangerous than spatial perturbations.

Conclusions. Instability of the flow of a nonuniformly heated binary mixture filling a vertical layer in a high-frequency vibrational field of longitudinal harmonic vibrations is considered within the framework of an averaged approach. Interaction of vibrational and gravitational mechanisms of convective instability is studied. Charts of stability of the flows of gas mixtures and salt solutions are obtained. In the case of liquid binary mixtures, the boundary of the stability region consists of different segments corresponding to neutral monotonic and vibrational modes. Vibrational perturbations have different frequency and spatial characteristics. Plane perturbations are demonstrated to be the most dangerous ones.

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