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Incompressible Perturbations in Uniformally Stratified Viscous Heat-Conducting Fluid

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One-component model of dissipative medium with two-parametric equation of state allows us to formulate a simple model of a stratified viscous heat-conducting fluid. At local thermodynamic equilibrium description and the simplifying assumption of constancy of the kinetic coefficients the complete system of equations of a viscous fluid can be written in the form of the equations of conservation of mass, momentum balance, entropy balance and state equation. Consequence of the equation of state is a linear relationship between changes in density and changes in pressure and entropy. In the case of an incompressible fluid change in the density does not occur when the pressure changes. This corresponds to an infinite speed of sound. As a result, change in the density is proportional to the temperature change and thermal expansion coefficient. Accordingly, the velocity of fluid flow is not solenoidal.
At the constant heat capacity the entropy balance equation reduces to the heat equation, which in turn takes the form of the evolution equation of the density. This equation completes the equation of conservation of mass and the equation of fluid motion. We assume that fluid flow occurs in the gravity field and is caused by small external forces, a small source of mass and small thermal source. Let the initial state of the fluid is rest with the vertical coordinate-dependent density distribution. For simplicity it is assumed also that the stratification is uniform, i.e. the buoyancy frequency is constant. Then the weak current caused by the sources will be described by the linearized equations with constant coefficients in Boussinesq approximation. In this approximation, square of buoyancy frequency, the density at a fixed level and the transport coefficients are the basic constant coefficients of the equations. Gravity selects the vertical direction, and therefore it is convenient to divide vector characteristics of the perturbation in the horizontal and vertical parts. In turn, the horizontal components of vectors is conveniently represented by pairs of scalar potentials using the Helmholtz decomposition. Taking into account these relations complete system of equations for small perturbations can be reduced to separate equations for the characteristics of the perturbations. As a result, small perturbations of density, pressure and vectors of velocity and vorticity can be expressed in the form of various derivatives of the five quasipotentials. Four of these quasipotentials obey the same equation of sixth order with the mass, force and heat sources, respectively, on the right side. The operator left-hand side of these equations reflects the behavior of internal waves, as well as viscous and thermal relaxation. In addition to the viscosity this operator includes the kinetic coefficient, which is directly proportional to the coefficient of thermal conductivity and is inversely proportional to the specific heat. In this case the vertical componen