LOGARITHMIC FLUIDS

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A living review of past, current and future studies of the so-called "logarithmic" fluids is presented. We begin by considering a large class of condensate-like strongly-interacting materials and many-body systems, which allow description in terms of a single macroscopic function, at least effectively or in a leading-order approximation. Recently proposed statistical mechanics arguments [1] and previously known Madelung hydrodynamical presentation [2] reveal that the logarithmic nonlinearity occurs in equations describing such matter. From the viewpoint of classical fluid mechanics, the resulting equations describe in the simplest case the irrotational and isothermal flow of a two-phase barotropic compressible inviscid fluid with internal capillarity and surface tension [3]. We demonstrate the emergence of Hilbert space and spontaneous symmetry breaking in this class of fluids, which leads to a number of wave-mechanical and topological effects [4].

The applications of such fluids can be found in both classical and quantum physics. In a classical case, one can show that the "logarithmic" fluids can be used for describing various Korteweg-type materials, such as magmas in volcanic conduits [3,4], whose studies have a long history [5].

In quantum physics, such fluids can be used for describing strongly-interacting quantum fluids [6-8], including He II, a superfluid component of He-4 [9]. We show the relationship between the "logarithmic" fluids and those described by polynomially nonlinear wave equations, such as the Gross-Pitaevskii one, which can be regarded as perturbative or low-density limits of the former [1].

Yet another range of applications of the "logarithmic" matter can be found in a theory of physical vacuum. Using the logarithmic model and machinery of condensed matter, one can formulate an essentially quantum post-relativistic theory which recovers special and general relativity in the "phononic" (low-momenta) limit, but otherwise has rather different tenets, foundations and predictions. We show that the paradigm of fundamental background superfluid opens up an entirely new prospective on the emergence of the Lorentz symmetry and spacetime notions, spontaneous symmetry breaking and mass generation mechanisms, finite-size elementary particles and Q-balls, dark matter/energy candidates, black holes, cosmological singularities, transluminal phenomena, and so on [10-15].

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