Induced spacetime and effective gravity in quantum liquids

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We shall begin by determining our working model of background superfluid. We focus on a large class of condensate-like strongly-interacting materials and many-body systems, which allow their description in terms of a single macroscopic wavefunction. 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 [3-10].

In the main part of the lecture, we shall see that relativistic 4D spacetime and gravity effectively emerge in non-relativistic quantum liquids in the ``phononic'' (low-momentum) limit, where acoustic oscillations (sound) play a role of light. This idea can be extrapolated to the fundamental background, also known as physical vacuum, and can be used to formulate a class of theories of gravity [11-14]. We introduce a concept of induced gravitational potential defined through a wavefunction of quantum liquid being in some quantum state. We illustrate a robustness of this approach by applications to astrophysics and cosmology.

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