A. M. Polyakov. *Phase transitions and the Universe.* The cosmological term in Einstein's equations would necessarily arise from the fact that the vacuum has a nonzero energy density because of the zero-point oscillations. If this energy density is estimated using the characteristic hadronic masses, a colossal value is obtained for the cosmological constant Λ. Moreover, for consistency with the experimental data on the red shift, the admissible value of Λ must be smaller than 10^{-130} of the natural hadronic estimate. To all appearances, there must exist a compensation mechanism which reduces the energy density of the vacuum to zero. The objective of this work is to find such a mechanism.

To solve this problem, we must first determine its correct formulation. The point is that energy is in general defined to within a constant, and therefore the choice of this constant seems unclear. However, everything falls into place if we study not the energy density, but the effective equations for the propagation of a gravitational field. By the word "effective" we mean the equations which arise from the original theory of Einstein as a result of infrared quantum renormalizations. It is very important to realize that in general the observed classical dynamics in any theory is determined by the effective equations rather than by the original ones. In certain cases (for example, in the Yang-Mills theory), the infrared renormalizations do not completely destroy the original classical theory. In the problem of interest to us—Einstein's theory with the bare cosmological constant—the role of the infrared normalizations is more modest. It will be shown that they lead to vanishing of the physical cosmological constant without affecting Einstein's equations themselves.

Infrared divergences occur in the theory because of the long-wave conformal fluctuations of the metric. If we write

$$g_{\mu\nu}(x) = \varphi^2(x)\,\bar{g}_{\mu\nu}(x) \tag{1}$$

[where $\bar{g}_{\mu\nu}$ has zero scalar curvature: $R(\bar{g}) = 0$] and average over all fluctuations of the field $\bar{g}_{\mu\nu}$, the low-energy Lagrangian of the field φ takes the form

$$\mathcal{L} = \frac{1}{2\varkappa}\left((\partial_\mu\varphi)^2 + \Lambda\varphi^4\right), \tag{2}$$

where $\varkappa$ is related to the gravitational constant, and Λ is the cosmological constant without allowance for the infrared oscillations. The problem of the cosmological term can now be formulated as the problem of whether the field φ has a nonzero vacuum expectation value. As can be seen from (1), if $\langle\varphi(x)\rangle = \text{const}$, the vacuum has zero scalar curvature, which means that the cosmological term vanishes. A phase with $\langle\varphi\rangle = 0$ would correspond to $\Lambda_{\text{phys}} \neq 0$. Since the Lagrangian (2) is scale-invariant, we can have $\langle\varphi\rangle \neq 0$ only for fixed boundary conditions. If we consider a region of dimension R (which must tend to infinity at the end of the calculations) and fix $\varphi = \varphi_\infty$ on the boundary of the region, two variants are possible:

$$\langle\varphi(0)\rangle \underset{R\to\infty}{\propto} \begin{cases} \varphi_\infty \to \text{const}, \\ \dfrac{1}{R} \to 0. \end{cases}$$

A calculation of the path integral of the Lagrangian (2) in the single-loop approximation shows that the first possibility is realized, and this means that the physical cosmological constant vanishes. The mechanism of vanishing is analogous to the phenomenon of zero charge in quantum electrodynamics discovered by Landau, Abrikosov, and Khalatnikov. It is related to the tendency of the long-wave fluctuations to screen the proper interaction.

In addition to the perturbative fluctuations considered above, screening can also arise from gravitational instantons. In our case, they are de Sitter worlds, which can be observed at any point x with finite probability; as a result,

$$\langle\varphi(x)\rangle \neq 0.$$

[1] I. D. Novikov and Ya. B. Zel'dovich, Relyativistskaya astrofizika (Relativistic Astrophysics), Moscow (1967), p. 561.

G. E. Volovik and V. P. Mineev. *Textures, vortices and superfluidity of* ^{3}He. In 1972 the discovery was made of the new A and B phases of liquid ^{3}He, which in subsequent years astonished physicists by their unique properties. Both new phases of ^{3}He, like the well-studied ^{4}He, are superfluids. The superfluidity of ^{4}He is a consequence of the phenomenon of Bose condensation of the macroscopic part of the atoms of the liquid in the ground state. Superfluidity of the normal Fermi liquid ^{3}He, like superconductivity of the electron Fermi liquid in metals, sets in as a consequence of Cooper pairing of the ^{3}He atoms. However, there is an important difference between the Cooper pairs in ^{3}He and in a superconductor. The total spin of a pair and the relative angular momentum in a superconductor are equal to zero, $S = L = 0$, i.e., the pair has no magnetic structure and is a spherically symmetric formation. In both phases of ^{3}He, $S = 1$ and $L = 1$. All pairs are in the same state; as a result, the liquid phases of ^{3}He have nontrivial magnetic properties reminiscent of the proper-