D. A. Kirzhnits and A. D. Linde. The Vacuum Phase Transition and Cosmology[1)] Recent years have seen significant progress in elementary-particle theory, progress that will, it is hoped, culminate in the construction of a unified (encompassing all particles and all of their interactions) theory that is free of inconsistences (see, for example[3]. This progress has been due to use of the idea of spontaneous symmetry violation, which has served as a basis for description of ordered states in macrophysics (superconductivity, ferromagnetism, and many others). In the new theory of particles, their masses are initially assumed equal to zero, which makes it possible to combine particles into multiplets and avoid the appearance of inconsistencies that do not submit to renormalization. However, the particles ultimately acquire the required mass as a result of spontaneous symmetry breaking—Bose condensation of a scalar field specifically introduced into the theory.

There is a profound and far-reaching analogy between the new particle theory and the theory of superconductivity. For example, boson masses result from the same mechanism that forms the basis for explanation of the Meissner effect, and fermion masses appear for the same reasons as the energy gap in a superconductor. This analogy suggests (and this is confirmed by an exact calculation) that at a sufficiently high temperature—on the order of 1—100 GeV in the various models—the particle system should undergo a phase transition with recovery of the originally broken symmetry and with loss of the particle masses; in a sufficiently strong external field, this transition can take place even at zero temperature. This also applies to a vacuum—a state with zero values of the total charges (electrical, baryon, lepton). The type of phase transition depends on the model chosen—it may be of either the first or second order.

When applied to the "hot" (big-bang) model of the universe, the pattern described above produces a number of cosmological consequences:

a) The density of the condensate depends on temperature, and, consequently, also on time. The same applies to such fundamental quantities as the masses of particles (they decrease with backward movement in time, disappearing after a certain instant) or the Fermi weak interaction constant (which, to the contrary, increases with motion backward in time, becoming infinite at the initial epoch, which corresponds to long-range action of the weak interaction).

b) Like an ordinary vacuum in field theory, the Bose condensate is manifested as a cosmological term in Einstein's equations. However, this quantity depends on time, so that an apparent violation of the energy balance arises as a result of its being "pumped" into the unobservable Bose condensate (or back).

c) At the epoch corresponding to the phase transition, buildup of the fluctuations, the appearance of nuclei, etc. should take place in the Universe. The possibility that this fact may prove essential for the as yet unsolved problem of the formation of galaxies can not be overlooked.

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1)This paper was based on the authors' publications [1] (see also [2].

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