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A scientific session of the Division of General Physics and Astronomy and of the Division of Nuclear Physics of the Academy of Sciences of the USSR was held at the Lebedev Physics Institute, Moscow, on February 23–24, 1983. The session heard these reports.

February 23

1. *É. L. Andronikashvili.* Microscopic model of metal-ion-induced carcinogenesis.

2. *A. D. Linde.* Phase transitions in the theory of elementary particles and an inflationary universe.

February 24

3. *G. V. Domogatskiĭ.* Outlook for future research on deep-underwater detection of muons and neutrinos at Lake Baikal.

4. *A. A. Tyapkin.* Diffractive production of resonances and observation of two radially excited states of the pion.

Two of these reports are summarized below.

A. D. Linde. *Phase transitions in the theory of elementary particles and an inflationary universe.* Contemporary unified theories of elementary particles are based on the principle of a spontaneous symmetry breaking which leads to a separation of interactions into weak, strong, and electromagnetic. The symmetry breaking results from the spontaneous appearance of constant classical scalar (Higgs) fields throughout space. In the simplest theories of this type, called "grand unified theories," scalar fields of two types arise: $\Phi\sim10^{15}$ GeV and $\varphi\sim10^{2}$ GeV. The field Φ results in the separation of the strong interactions from the electroweak interactions, while the field φ separates the weak and electromagnetic interactions.[1]

Study of large systems of particles interacting in accordance with the unified theories has shown that as the temperature (T) of the medium is increased the scalar fields φ and Φ disappear (at temperatures $T_{c1}\sim10^{2}$ GeV and $T_{c2}\sim10^{14}$ GeV, respectively), and the symmetry among all types of interactions is restored.[2]

An important consequence is the restoration of symmetry among the strong, weak, and electromagnetic interactions in the early universe, when the temperature of matter exceeded 10^{14} GeV. During the expansion of the universe the temperature fell, and there was a series of phase transitions accompanied by a breaking of symmetry because of the appearance of the fields Φ and φ. Although these phase transitions occurred only very early in the evolution of the universe (at $t_{c2}\sim10^{-35}$ s and $t_{c1}\sim10^{-10}$ s, respectively, where t is the expansion time of the universe), they can have several important consequences for the present state of the universe. In certain grand unified theories the corresponding consequences are contradicted by existing cosmological data. This contradiction imposes some severe restrictions on the types of theories.

For example, in theories with relatively light Higgs bosons[3] and also in the simplest supersymmetric Grand Unification theories[4] the phase transition is stretched out too much and could not occur over the lifetime of the universe, $t\sim10^{10}$ yr. In theories with a spontaneously broken discrete symmetry (with a spontaneously broken CP invariance, for example) the phase transition should have been followed by the formation of heavy domain walls, which would severely disrupt the isotropy of the universe.[5] The most unacceptable effects have been found in a study of the production of magnetic monopoles with masses $m_M\sim10^{16}$ GeV should have been produced in large numbers during the phase transitions in essentially all the Grand Unification theories, and an unacceptably large number of monopoles would have to remain today.[6] The problem of relict monopoles has raised serious doubt regarding the compatibility of present cosmological ideas and the present theory of elementary particles.

The only known way to resolve this problem of relict monopoles is to appeal to the so-called new scenario of an inflationary universe[7] (a first version of this scenario was proposed in Ref. 8, but it proved to be contradicted by cosmological data). This scenario can be summarized as follows: In certain types of Grand Unification theories a phase transition accompanied by the appearance of a field $\Phi\sim10^{15}$ GeV occurs during the expansion of the universe because of a greatly supercooled symmetric phase with $\Phi=0$. The energy density of matter (elementary particles) in this supercooled phase falls off rapidly during the expansion of the universe, and the total energy density of matter reduces to the energy density of an unstable vacuum state with $\Phi=0$. The result is an exponentially rapid expansion of the universe in an unstable state with $\Phi=0$. The expansion remains exponential in the early stages of the symmetry-breaking process, before the field Φ has become large. If the time over which the field Φ increases from zero to its equilibrium value $\Phi\sim10^{15}$ GeV is long enough, the universe will be able to undergo a tremendous expansion during this time. As a result, the monopoles produced during the phase transition would be separated by huge distances, so that their density would become negligibly small.[7]

It turns out that in principle this scenario can solve not only the relict-monopole problem but also several other cosmological problems, such as the problems of

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the horizon, flatness, homogeneity, and isotropy of the universe[7] and the problem of the origin of the density inhomogeneities required for the formation of galaxies.[9] This new scenario of an inflationary universe can be realized completely, however, only in theories which satisfy certain conditions on (for the most part) the nature of the potential energy $V(\Phi)$ of the scalar field Φ (Refs. 7 and 9). The derivation of realistic theories of this type is an important and interesting problem in the modern theory of elementary particles.

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