where L is the dimension of the sample and $\Delta\varphi$ is the potential difference at its ends. We note in conclusion that effects similar to those considered above take place also for the remaining kinetic coefficients of a metal in a magnetic field.

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PHYSICAL LIMITATIONS ON THE TOPOLOGY OF THE UNIVERSE

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In general relativity theory, rejection of the simple assumption of a flat Euclidian space raises naturally the question that the topology of space (three-dimensional as well as four-dimensional space-time) can differ from the simple topology of flat space for an open world or the topology of a sphere for a closed world.

Shortly following Einstein's first paper [1] on the cosmological problem, in which he constructed a static cosmological model with a closed spherical three-dimensional space, Klein [2] indicated that a three-dimensional space with the same metric can also be elliptic,* i.e., it can have on the whole other properties than a spherical space.

The question of the connectivity of the space as a whole and of its topology is continuously mentioned in the literature (see [3]).

The nonstationary nature of the universe and the probable existence of a singularity in the past obviously limits the region accessible to observation and hinders a direct observational investigation of the topology, say by observing the same remote object in opposite directions. Interest attaches therefore to those limitations that can be imposed on the topology by starting from considerations that do not depend on astronomic observations.

One such limitation is the requirement that causality be satisfied. This requirement is incompatible with manifolds containing closed timelike world lines (see [4,5]).

The purpose of the present note is to emphasize that recent discoveries in the physics of elementary particles, which make possible absolute definitions of "right" and "left," show that a real physical three-dimensional space cannot be non-orientable (this cannot be refuted a priori). It is known that non-orientable three-dimensional spaces are contained, for example, among the 18 possible spaces of constant zero curvature (among both the open and the closed ones)** [6].

Suveges [6] emphasizes that in a non-orientable space inversion is a continuous transformation (and not discrete, as in an orientable space).

In this note we draw some physical conclusions from this remark by Suveges.

In a non-orientable space there exists a contour such that a circuit over it transforms a right-hand system into a left-hand one, i.e., a circuit over such a contour is equivalent to the operation of space reflection (P). This fact was noted also by Schild [11] in a discussion of a paper by Zumino at the Pisa Conference of 1964.

In 1956, discovery of parity nonconservation in weak interactions made it possible to define uniquely the concepts of a "right" and "left" system, and therefore a real physical space cannot be non-orientable.***

This statement cannot be made if it is assumed that a circuit over a non-oriented contour transforms a particle into an antiparticle, i.e., the circuit corresponds to combined parity (CP), since, according to Landau's hypothesis, it is precisely such a combined inversion which conserves the right-left symmetry of empty space.

Thus, in a non-orientable space, if CP-invariance holds, the question of whether two remote particles are identical or are a particle and antiparticle depends on the path along which they are brought to the same point.

The discovery of CP-invariance violation in K_2^0-meson decay allows us to predict an absolute difference between matter and antimatter (see [8]) and by the same token excludes any possible existence of non-orientable continuous space. It is obvious that in such a space the properties of particles should change jumpwise on going over a non-orientable contour, which is impossible.****

We emphasize that the foregoing conclusions do not depend on the nonstationary nature of the co-moving space in cosmology, nor do they depend on whether we are able to go around the world, in a cosmological model that expands from a singularity, by moving not faster than light along a closed contour that gives space reflection. Indeed, we can consider a chain of particles situated along this contour, compare the properties of particles that lie alongside each other, and arrive at the same contradiction.

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* A space is called elliptic if diametrically opposite points of a three-dimensional sphere are identified in it.

** There ar no non-orientable spaces among the three-dimensional spaces of positive constant curvature.

*** The fact that parity nonconservation should be of significance to astrophysics was emphasized by Pontecorvo [7]. Shapiro [9] related parity nonconservation with non-orientability of space in the small ($l \sim 10^{-17}$ cm); the importance of the topological properties of space to physics was emphasized by Wheeler a number of times [10]. In this note we speak of non-orientability on a cosmic scale.

**** If the mirror-particle hypothesis turns out to be valid (see [8]), then symmetry between right and left will be restored. In this case a non-orientable space becomes possible under the condition that a circuit over a non-orientable contour corresponds to CPA inversion (A - transformation into a mirror particle).

UPPER LIMIT OF ELEMENTARY LENGTH

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1. Lindenbaum [1] recently derived from a comparison of new data on forward πp scattering and the dispersion relations the following estimate

$$l < 0.7 \times 10^{-15} \text{ cm} \tag{1}$$

Here l is the elementary length, i.e., a quantity determining the dimensions of the space-time region in which violation of the general principles of elementary-particle theory is possible.

Lindenbaum's result is of considerable interest, being more effective by approximately one order of magnitude than the earlier estimates based on verification of quantum electrodynamics (cf., e.g., [2]). However, the relation $l < 1/\omega_L$ (ω_L is the energy in the laboratory system) used in [1] and leading to (1) is subject to serious objections and can hardly be justified.

2. The correct method for determining the upper limit of l, the one usually employed in the reduction of the results of electrodynamic experiments, is based on introducing into the expression for the measured quantity (A) certain factors that violate the general principles of the theory, most frequently locality. As a result, A acquires a correction term δA, which depends on l. If there is no discrepancy between experiment and local theory (within an accuracy Δ), then we have the obvious inequality

$$|\delta A(l)| < \Delta, \tag{2}$$

which can be used to determine the upper limit of l.

Unfortunately, the use of this method in our problem is made very difficult by the impossibility of exactly calculating $|\delta A|$ (strong interactions). It is possible, however, to obtain for this quantity a lower bound, from which definite conclusions can be drawn regarding the plausibility of the inequality (1).

3. To obtain the nonlocal correction to the dispersion relations, we shall use the nonlocal scheme proposed by Leznov and the author [3] and satisfying the requirements of relativism, correspondence, convergence, and (with certain stipulations) microcausality (see also [4]).* This scheme is based on an expanded Hilbert space of states, containing besides the usual states also auxiliary unphysical states with negative norm and with masses $\kappa \geq 1/l$. We construct the local theory on this expanded space in the usual manner, and use in lieu of the usual field operators φ, ψ, etc. the combinations