through all the steps mentioned in Sec. 3, we obtain for η the same expression (7), but now $\gamma = \gamma_0 + \beta T_c/\Delta$, where $\gamma_0 = \gamma_N + \gamma_{R_0}$ and $\beta > 0$. Thus the quantity

$$\eta_0 = \frac{a}{2} \gamma_0 \sigma \Phi_0 H_{c_2} c^{-2} \approx 1.47 \sigma \Phi_0 H_{c_2} c^{-2} \tag{8}$$

is the lower bound of the friction coefficient in a superconductor having a high nonmagnetic-impurity concentration.

At a certain deviation from T_c, where the applicability of the Ginzburg-Landau equations can still be expected), the second term of γ becomes practically constant. In this region the excess of the friction coefficient over the minimum value (8) is determined by the ratio of the quantities γ_0 and β, the latter being unknown. An analysis of the presently known experimental data likewise fails to answer this question, since these data give values of γ that differ greatly (by as much as a factor of 3) at the same values of T/T_c.

It can only be noted that such factors as the presence of local excitations in the vortex core [5] or inhomogeneities of the material [6] lead to a smearing of the singularity in the excitation spectrum and by the same token to a decrease of the anomalous terms that give rise to the increment of γ_0. It is possible that the already mentioned strong scatter of the experimental values of the friction coefficient is due just to the fact that these and similarly acting factors cannot be controlled.

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POSSIBLE EXISTENCE OF HADRONIC ISOMERS

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This article deals with the angular momenta of micro-objects (say molecules, atoms, atomic nuclei, and the so-called elementary hadrons), which have finite dimensions and can assume different excited states. In spite of the great differences between the dimensions of such quantum objects, there is a certain similarity between them. The angular momentum is the product of the momentum p by the radius R. Owing to the uncertainty relation we have $p \sim R^{-1}$, so that examination of the angular momenta reveals a unique similarity between quantum objects that differ strongly in their scales and in their mean energy distances between excitation levels. This similarity suggests that we might be able to consider heuristically the behavior of objects of a known structure, such as atomic nuclei to gain an idea of the behavior of objects whose structure is known and linear dimensions are smaller, such as hadrons.

The hypothesis that hadrons consist of partons may help us to probe for the analogy, but not more. It is important that the hadrons have a very complicated structure, and that in spite of this complexity their excitation levels can be well separated.

As is well known, metastability of the levels is frequently observed in atomic nuclei, i.e., the existence of individual states with lifetimes much longer than those of "ordinary" levels with comparable excitation. As a rule, the metastability is connected with the large angular momenta of excited states having relatively low excitation (nuclear isomerism). At the present time we know of a tremendous number of nuclear isomers whose maximum excitation equals several MeV. The measured lifetimes of the nuclear levels range from 10^{-17} to 10^{11} sec! There are known nuclear isomers with angular momenta exceeding $J = 15$.

Why not consider such large values of J for hadrons? This raises the question of the possible metastability connected with large values of J also in the field of hadron physics. In other words, do hardonic isomers exist? They are defined here as not too highly excited hadrons having large values of J and emitting upon decay, say, pions (or photons if the excitation is accordingly low) with a lifetime that is very large because of the centrifugal barrier.

It turns out that it is difficult to exclude this possibility on the basis of our present knowledge of hadron physics. We confine ourselves to two remarks.

1. The fact that not a single example of hadron isomerism connected with large angular momenta has been observed to date does not mean in any way that this phenomenon does not exist. As will be shown below, if hadronic isomers do exist, they can probably not be observed in the hitherto performed experiments, and can be found only by specially organized experiments.

2. Naturally, those levels of a quantum object which have large angular momenta have in general a high excitation. Exceptions are possible, however. For isomerism to appear it is necessary, as a rule, to have sometimes "inversion" of the levels, whereby some state with a very high angular momentum has a relatively low excitation. In the case of atomic nuclei, as is well known, such an "inversion" takes place quite frequently, and is connected with the nuclear structure (orbitals, magic numbers, shape). In the case of hadrons, in my opinion, nothing definite can be said from the theoretical point of view. On the other hand, the empirical data on hadronic resonances are scanty and it is impossible to perform on their basis a statistical analysis that would exclude level inversion. To the contrary, the data suggest that the aforementioned inversion can always take place. For example, there are well known [1] four pairs of bosons, η and η', $\eta_{0+}(700)$ and $\eta_{0+}(1070)$, ω and ϕ, and f(1260) and f'(1514), each of which (insofar as we know) have identical quantum numbers, but the masses differ by several hundred MeV. For baryons there seems to be [1] "inversion" for N(1688) $J^P = 5/2^+$ and N(1780) $J^P = 1/2^+$, N'(1670) $J^P = 5/2^-$ and N"(1700) $J^P = 1/2^-$, $\Delta(1236)$ $J^P = 3/2^+$ and $\Delta(1910)$ $J^P = 1/2^+$, $\Delta(1890) \cdot J^P = 5/2^+$ and $\Delta(1910)$ $J^P = 1/2^+$, $\Lambda'(1520)$ $J^P = 3/2^-$ and $\Lambda'(1670)$ $J^P = 1/2^-$, and others. These circumstances, of course, may be due to a number of factors, particularly to the existence of an additional quantum number (such as the principal quantum number n in atoms), but in any case "inversion" cannot be excluded.

When it comes to experiments aimed at searching for hadronic isomers, we should stop to discuss their possible properties. Let us consider by way of an example two-particle decay of a hadronic isomer with emission of particles having a momentum K. At $KR \lesssim 1$, i.e., at sufficiently low excitation of the hadromic isomer (say, <1 GeV) and at sufficiently large angular momenta, the isomer lifetimes τ_i can reach values larger by many orders of magnitude than the lifetime τ of ordinary hadronic resonances, say $\tau_i >> \tau \leq 10^{-21}$ sec). Owing to the small width of the hadronic isomers, they cannot be observed by studying elastic collisions of two particles, as is done for the study of, say, baryons of type N and Δ in pion-nucleon collisions. The hadronic isomers should be revealed by their decay properties.

Naturally, the cross sections for inclusive hadronic-isomer production (i.e., production of an isomer jointly with some other hadrons) is negligible at low energies and can be noticeable at energies so high that the contributions of partial waves with large orbital angular momenta become significant. The cross section for the production hadronic isomers is expected to be lower, even at very high energy, than the cross section for the production of "ordinary" narrow hadrons (such as kaons or hyperons) with low spin values.

The foregoing explains why hadronic isomers have not been observed to date, even if they exist. Namely, at "short" lifetimes (say $\tau_i \lesssim 10^{-12}$ sec), when the length to decay of hadronic isomers produced in the existing accelerators is not observable in a bubble chamber, the observation of hadronic isomers is equivalent, from the experimental point of view, to observation of ordinary resonances with small cross section σ (it is very difficult to observe $\sigma < 10^{-30}$ cm^2).

As the accelerator energies are increased (Serpukhov, Batavia), observation of nuclear isomers becomes more realistic not only because the contribution of the partial waves with large orbital angular momenta is larger, but also because the length to decay can be observed. At a Lorentz factor ∿50 it is possible to observe $\tau_i \gtrsim 10^{-12}$ sec in a bubble chamber and in $\tau_i \gtrsim 10^{-15}$ sec photographic emulsions. When organizing the experiments it is therefore necessary to pay attention to searches for "cascade decays" (bound "stars"). The latter may turn out to be quite typical. If for example, the hadronic isomer is a hyperon, its "signature" might consist of three (or more) bound events (isomer production, isomer decay with Λ-particle emission, decay of Λ).

On the other hand, if some hadronic isomer were to have a lifetime $\tau_i \gtrsim 10^{-9}$ sec and were to be electrically charged, then it would become observable in the already performed experiments [2] if its production cross section were larger than $\sim 10^{-31}$ cm^2 and its mass were less than 2.2 GeV.

The organization of experiments now under way and aimed at finding new long-lived particles was discussed in earlier papers [3]. The hadronic isomerism connected with the large values of J has so far not been considered as a possible cause of metastability. In these experiments, searches are made for "radioactivity" of the quasinucleus in which the new particle might be captured. It is possible to raise in this connection the question of the fate of a long-lived hadronic isomer if it is captured inside of a nucleus. One can apparently expect such a hadronic isomer to experience "internal conversion" similar to mesonless decay of hypernuclei. The process of energy transfer directly to the nucleon of the nucleus will then prevail, and the lifetime is greatly shortened relative to the lifetime of the free isomer. This question was discussed by Kobzarev and Okun' 15 years ago, when the cause of the metastability of the Λ particle was not yet firmly established.

After the idea described here was formulated, I learned of work by Japanese physicists [5], who observed a particle with mass ∿2 GeV and a lifetime $\sim 10^{-14}$ sec. Such a mass is so large, that it is not very likely that this particle is a hadronic isomer in the sense discussed above (if we disregard values $R << 1/m\pi$).

I consider searches for hadronic isomers to be timely both with high-energy accelerators and in cosmic rays.

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LIMITATIONS ON CURRENTS OF THE SECOND CLASS IN THE PROCESS $\nu_\mu + n \rightarrow p + \mu^-$

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The presently available experimental data on the total cross section of "elastic" neutrino scattering, $\nu_\mu + n \rightarrow p + \mu^-$ [1], yield the upper bound of the tensor constant of a current of the second class and mass limitations for the axial-vector form factor in weak interactions.

To this end, we represent the hadronic weak-interaction current in the form

$$J_\mu = \frac{G}{\sqrt{2}}\bar{p}\left[(f_V\gamma_\mu + f_M\sigma_{\mu\lambda}q_\lambda) + if_s q_\mu + (f_A\gamma_\mu + if_p q_\mu)\gamma_5 + f_T\sigma_{\mu\lambda}q_\lambda\gamma_5\right]n \tag{1}$$

$$= J_\mu^{V(1)} + J_\mu^{V(2)} + J_\mu^{A(1)} + J_\mu^{A(2)},$$

where $q_\lambda = (n - p)_\lambda$ is the momentum transfer, $G = 10^{-5}M^{-2}$ the weak-interaction constant, and M the nucleon mass.

In expression (1), the vector and axial-vector currents of the second class [2], $J_\mu^{V(2)}$ and $J_\mu^{A(2)}$, have G-parities opposite to the G-parities of the corresponding first-class currents $J_\mu^{V(1)}$ and $J_\mu^{A(1)}$. When T-invariance is violated, the constants of the current (1) become complex. In a model in which T-invariance of weak interaction is violated only by second-class currents [4], the imaginary part of the tensor constant f_T is of the order of

$$\mathrm{Im} f_T \sim M^{-1}. \tag{2}$$

This value does not contradict experiments on the measurement of T-odd correlations in decays of a polarized neutron [4] and of the nucleus F^{19} [5]:

$$\mathrm{Im}\, f_T = (20 \pm 20)M^{-1}[4], \tag{3}$$
$$\mathrm{Im} f_T = (4 \pm 28)M^{-1}[5].$$