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A joint scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciences was held on October 22 and 23, 1980 at the P. N. Lebedev Physics Institute of the USSR Academy of Sciences. The following papers were delivered:

October 22

1. *G. V. Domagatskiĭ, D. K. Nadezhin, and R. A. Eramzhyan*, The Origin of the Chemical Elements and the Role of the Neutrino.

2. *V. A. Kuz'min*, Nonconservation of Baryons: Cosmological and Experimental Implications

October 23

3. *V. S. Troitskiĭ, A. V. Gustov, I. F. Belov, V. M. Plechkov, V. P. Gorbachev, and L. K. Siz'mina*, Possibile Use of the Intrinsic Microwave Thermal Radio Emission of the Human Body to Measure the Temperatures of Its Internal Organs: Results and Prospects.

4. *N. D. Devyatkov, É. A. Gel'vich, I. B. Davydova, V. V. Kirillov, D. N. Kolmakov, V. N. Mazokhin, V. I. Sinyagovskiĭ, and P. I. Chilikin*, Microwave and Radio-Frequency Apparatus and Methods for Use in Oncology.

5. *V. B. Shteĭnshleĭger, G. S. Misezhnikov, and A. G. Sel'skiĭ*, A Radiophysical Method for Detection of Thermal Anomalies in Human Internal Organs.

Brief summaries of four of the papers are published below.

V. A. Kuz'min. *Nonconservation of Baryons: Cosmological and Experimental Implications*. There is now weighty evidence in favor of the idea that the law of conservation of baryon number (B) is not absolutely exact:

1. The absence of antimatter in the Universe and the baryonic asymmetry of the Universe (BAU) (i.e., the ratio of the densities of baryons and photons) can be explained successfully by invoking a B-violation hypothesis.[1,2]

2. Nonconservation of B proceeds naturally from the unified gauge theories (UGT) of strong, electromagnetic, and weak interactions. The strong points of these theories are prediction of the Weinberg angle, explanation of electric-charge quantization, mass formulas for fermions, the possibility of predicting numbers of fermion generations, and, finally, explanation of the baryonic asymmetry of the Universe. These models also predict instability of the proton, and, surprisingly, its lifetime falls in a range that is just accessible to experimental verification.

Necessary conditions for the appearance of the BAU are: nonconservation of B and C, CP violation, and thermodynamic nonequilibrium.[5] The first two conditions are usually satisfied in the UGT, while the last one is met at certain stages in the expansion of the Universe.

The existence and magnitude of the BAU impose extremely rigid constraints on UGT structure, and specifically:

1) the SU(5) model must contain two quintets of scalar fields;[6]

2) in the SO(10) model, weak right-hand gauge bosons must be super-heavy, $M_{W_R} \gtrsim 10^{12}$ GeV;[8]

3) generation of BAU in decays of vector leptoquarks (X) is possible only if[9]

$$M_X \geqslant 5\cdot 10^{15}\ \text{GeV},\quad \frac{M_H}{M_X} \approx 0{,}7-0{,}9,\quad \frac{f}{4\pi} \approx (0{,}6-1.2)\,\alpha_{\text{GUM}},$$

where f is the Yukawa coupling constant and M_H is the mass of the scalar boson;

4) the magnitude of the BAU generated in decays of scalar particles (H) is at maximum when[9]

$$\frac{M_H}{M_X} \approx 3-7;$$

5) the minimal unified model[10] based on the group $[SU(4)]$, in which violation of B occurs spontaneously simultaneously with violation of the SU(3) color (i.e., at energies $\lesssim 1$ GeV), is rejected by cosmology.[11] Along with proton decay, certain UGT models also predict the existence of weak neutron-antineutron oscillations in vacuum ($n \to \bar{n}$ transition).

The importance of experimental searches for any processes with B-nonconservation and especially $n \to \bar{n}$ oscillation processes was pointed out by Sakharov.[1] He also studied the $n \to \bar{n}$ process phenomenologically and made estimates of the possible oscillation rates.

The results of experiments in search of instability of nuclei lead to the following limit on the period of $n \to \bar{n}$ oscillations:[15]

$$T \geqslant 1\cdot 10^{8}\ \text{sec.}$$

The weaker constraints on T given in Refs. 16 and 17 were based on poorly conditioned allowance for the overlap of the nuclear wave functions.

The experimental scheme might look like this: Having traveled a certain distance R in a vacuum, a thermal-neutron flux from an atomic reactor strikes a target. The appearance of antineutrons can be detected from the annihilation reaction that they trigger in the target. In order to detect oscillations with periods $T \approx 10^8$ sec, the sensitivity of the experiment (i.e., the beam antineutron: neutron density ratio that can still be detected) must be

$$p = \frac{\bar{n}}{n} = 9 \cdot 10^{-20}$$

at $R \approx 10$ meters. To eliminate the influence of the earth's magnetic field, it is sufficient to reduce it by a factor of 20 to 30.

Attempts might be made to increase the sensitivity of the experiment by using ultracold neutrons. However, analysis indicates that this would not raise sensitivity appreciably. In our opinion, the proposed experiment is an important independent excursion in the search for interactions that do not conserve baryon number.

At this writing (November 1980), an experiment in search of the oscillations is being conducted at the Laue-Langevin Institute (Grenoble) in collaboration with the Universities of Sussex and Padua, the Rutherford Laboratory, and CERN.

[1] A. D. Sakharov, Pis'ma Zh. Eksp. Teor. Fiz. **5**, 32 (1967) [JETP Lett. **5**, 24 (1967)].

[2] V. A. Kuz'min, *ibid.* **13**, 335 (1970) [**13**, 238 (1970)].

[3] A. Yu. Ignatiev, N. V. Krasnikov, V. A. Kuzmin, and A. N. Tavkhelidze. In Proc. Intern. Conference Neutrino–77, Moscow, **2**, 293 (1978); Phys. Lett. Ser. B **76**, 436 (1978).

[4] S. Weinberg, Phys. Rev. Lett. **42**, 850 (1979).

[5] L. B. Okun and Ya. B. Zeldovich, Comments on Nucl. and Part. Phys. **6**, 69 (1976). S. Dumopoulos and L. Susskind, SLAC–PUB–2126 (1978). A. Yu. Ignatiev, V. A. Kuzmin, and M. E. Shaposhnikov, IYaI Preprint P–0102 (1978).

[6] A. Yu. Ignat'ev, V. A. Kuz'min, and M. E. Shaposhinkov, Pis'ma Zh. Eksp. Teor. Fiz. **30**, 726 (1979) [JETP Lett. **30**, 688 (1979)]. S. Barr, G. Segre, and H. A. Weldon, Phys. Rev. Ser. D **20**, 2494 (1979). T. Yanagida and M. Yoshimura, Preprint TU/79/199.

[7] A. Yu. Ignatiev, V. A. Kuzmin, and M. E. Shaposhnikov, Phys. Lett. Ser. B **87**, 114 (1979).

[8] V. A. Kuzmin and M. E. Shaposhnikov, Phys. Lett. Ser. B **92**, 115 (1980).

[9] V. A. Kuz'min and M. Shaposhnikov, IYaI AN SSSR Preprint P–0190, Moscow (1981).

[10] J. C. Pati, Maryland Preprint No. 79–146 (1978).

[11] A. Yu. Ignat'ev, V. A. Kuz'min, and M. E. Shaposhinkov, IYaI AN SSSR Preprint P–0194, Moscow (1981).

[12] S. Hawking, Comm. Math. Phys. **43**, 199 (1975).

[13] Ya. B. Zel'dovich, Pis'ma Zh. Eksp. Teor. Fiz. **24**, 29 (1976) [JETP Lett. **24**, 25 (1976)].

[14] M. A. Markov, IYaI Preprint P–0187 (1980).

[15] M. V. Kazarnovskii, V. A. Kuz'min, K. G. Chetyrkin, and M. E. Shaposhnikov, Pis'ma Zh. Eksp. Teor. Fiz. **32**, 88 (1980) [JETP Lett. **32**, 82 (1980)].

[16] S. L. Glashow, Preprint HUTP–79/A059.

[17] R. N. Mohapatra and R. E. Marshak, Phys. Rev. Lett. **44**, 1316 (1980).