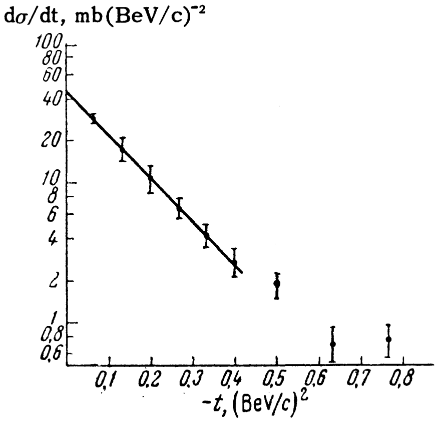

Differential cross section of elastic π^-p scattering.

$$T_p \sim i\sigma_{\text{tot}}\, s^{\alpha(t)}, \tag{1}$$

where s is the square of the total c.m.s. energy and $\alpha(t)$ is the trajectory of the vacuum pole. Taking into account the optical theorem we obtain

$$\frac{d\sigma}{dt} = \left(\frac{d\sigma}{dt}\right)_{t=0} S^{2[\alpha(t)-1]} = \left(\frac{d\sigma}{dt}\right)_{t=0} e^{2\ln s[\alpha(t)-1]}. \tag{2}$$

In the region of small t, recognizing that $\alpha(0) = 1$ and assuming that $[d\alpha(t)/dt] = \epsilon$, we get

$$\frac{d\sigma}{dt} = \left(\frac{d\sigma}{dt}\right)_{t=0} e^{2\varepsilon t \ln s} = \left(\frac{d\sigma}{dt}\right)_{t=0} e^{A(s)t}. \tag{3}$$

The values of A(s) determine the width of the diffraction maximum. It follows from (3) that the A(s) should increase with increasing s logarithmically, corresponding to a contraction of the difraction maximum with increasing s.

The calculation of A(s) from the results presented in the figure leads to a value $A = 7.36 \pm 0.44$ $(\text{BeV}/c)^{-2}$, which agrees well both with data at higher energies (see [2-6]) and at lower ones (see [2,7-10]). The energy interval investigated in these references is 1.5–16 BeV (s ranges from 3 to 30 BeV^2). The average of A(s) in the 1.5–16 BeV interval is 7.61 in accord with the data of [2-10] and the present work. If we assume that A(s) does not vary in the investigated interval of s and is equal to 7.61, then $\chi^2 = 13.1$ for this hypothesis at 12 degrees of freedom (40% confidence level), i.e., the use of the χ^2 criterion does not contradict the assumed constancy of A(s). For pp scattering, as is well known, a clear-cut narrowing of the diffraction maximum is observed with increasing s. Thus, the assumption that πp and pp scattering are determined by the contribution of the vacuum pole only contradicts the aggregate of the available experimental data.

In conclusion we consider it a pleasant duty to express deep gratitude to S. Ya. Nikitin for continuous interest in the work and to R. S. Guter for carrying out the calculations. The work was greatly helped by the painstaking work of the data-reduction group headed by D. I. Tumanova, to whom we express our sincere gratitude.

[1] G. F. Chew and S. C. Frautschi, Phys. Rev. Lett. **8**, 41 (1962).

[2] Ting, Jones, and Perl, Phys. Rev. Lett. **9**, 468 (1962).

[3] R. G. Thomas, Phys. Rev. **120**, 1015 (1960).

[4] Wang, Wang, et al, JETP **38**, 426 (1960), Soviet Phys. JETP **11**, 313 (1960).

[5] Czapek, Kellner, and Pietschmann, Phys. Lett. **1**, 226 (1962).

[6] Aĭntudinov, Zombkovskiĭ, Nikitin, and Selektor, JETP **42**, 1495 (1962), Soviet Phys. JETP **15**, 1038 (1962).

[7] Bertanza, Carrara, Drago, Franzini, Mannelli, Silvestrini, and Stoker, Nuovo cimento **19**, 467 (1961).

[8] Chretien, Leitner, Samios, Schwartz, and Steinberger, Phys. Rev. **108**, 383 (1957).

[9] Lai, Jones, and Perl, Phys. Rev. Lett. **7**, 125 (1961).

[10] R. C. Whitten and M. M. Block, Phys. Rev. **111**, 1676 (1958).

Translated by J. G. Adashko
71

SEARCH FOR ANTIMATTER IN COSMIC RAYS

N. L. GRIGOROV, D. A. ZHURAVLEV, M. A. KONDRAT'EVA, I. D. RAPOPORT, and I. A. SAVENKO

Institute of Nuclear Physics, Moscow State University

Submitted to JETP editor May 29, 1963

J. Exptl. Theoret. Phys. (U.S.S.R.) **45**, 394 (August, 1963)

WE placed on the second space ship (August 19, 1960) a stack of 489 type BR 10 by 10 cm pellicles 400 μ thick. The stack was exposed beyond the limits of the atmosphere at an approximate altitude of 300 km for about a day. After it was returned to earth and chemically developed, the stack was scanned with an aim of observing antinuclei [1]. The scanning was with an MBI-2 microscope with overall magnification of 105. In the course of scanning we identified the multiply charged nuclei stopped in the emulsion and the stars produced by multiply-charged nuclei. Since the scanning was at low magnification, the primary alpha-particles were barely registered, and only particles with $Z > 2$ were selected.

The scanning of the stack for antinuclei is now complete. We investigated 1079 stopped ordinary nuclei and 748 stars. None of the stars can be regarded as resulting from annihilation of a stopped antinucleus. We therefore conclude that the number of antinuclei with $Z > 2$ (at any rate, low-energy antinuclei) in primary cosmic radiation does not exceed 0.1%.

[1] Grigorov, Zhuravlev, Kondrat'eva, Rapoport, and Savenko, Iskusstvennye sputniki Zemli (Artificial Earth Satellites), No. 10, 1961, p. 96.

Translated by J. G. Adashko
72

DYNAMIC PROTON POLARIZATION AT 0.5°K

B. S. NEGANOV, L. B. PARFENOV, V. I. LUSHCHIKOV, and Yu. V. TARAN

Joint Institute for Nuclear Research

Submitted to JETP editor June 1, 1963

J. Exptl. Theoret. Phys. (U.S.S.R.) **45**, 394-396 (August, 1963)

SEVERAL successful experiments were recently carried out on dynamic proton polarization (DPP) in $La_2Mg_3(NO_3)_{12} \cdot 24H_2O$ crystals with impurities of paramagnetic cerium [1-3] and neodymium [4] at temperatures 1.4—1.7°K. The greatest proton polarization (51%) was obtained by Schmugge and Jeffries [4] through the use of a strong magnetic field (~ 20 kOe) and a high electron paramagnetic resonance (EPR) saturation frequency (~ 50 Gc). Further increase of the magnetic field and of the EPR frequency involves serious technical difficulty, particularly in the polarization of large targets (~10 cm³). At the same time, an increase in polarization could be obtained by using the progress made in obtaining stationary temperatures of 0.3—0.5°K if, of course, the coefficient of dynamic amplification does not drop sharply in this case.

We report here the results of preliminary DPP experiments in a double-nitrate crystal with a cerium concentration 0.8% (relative to lanthanum) at ~ 0.5°K. The investigated specimen with dimensions $6 \times 6 \times 2$ mm was placed in a quartz ampoule and inserted in a resonator kept at 1°K through a hole in the plunger. The ampoule was filled with liquid He^4, which produced the thermal contact between the specimen and a liquid He^3 bath, the temperature of which was regulated by the pumping rate of its vapor.

The specimen was placed in the resonator in such a way that the crystal hexagonal axis was perpendicular to the external magnetic field H_0.

In this case the g-factor of the Ce^{3+} ion is equal to $g_1 = 1.83$. The resonator was excited in the H_{102} mode with frequency $\nu_e = 9000$ Mc.

The increase in the proton polarization in the crystal with EPR saturation of the "forbidden" transitions of the Ce^{3+} ions was determined from the amplification of the nuclear magnetic resonance (NMR) signal of the protons. The NMR signal was detected by an autodyne circuit with automatic control of the oscillation level. Special measures were employed to eliminate the influence of the NMR saturation on the measurement results. At the minimum autodyne oscillation level attained in our installation, the NMR saturation effect was practically nonexistent. The measurements were made at several values of the autodyne oscillation levels. The true result was obtained by extrapolating the experimental data to the zero oscillation energy level.

We observed in the temperature region 0.5—1.7°K a noticeable increase in the proton polarization and investigated the following:

1) The dependence of the proton polarization amplification coefficient on the value of the external magnetic field at a fixed EPR frequency.

2) The dependence of the amplification coefficient on the microwave EPR saturation power.

3) The dependence of the proton spin-lattice relaxation time $T_{1\,nuc}$ on the temperature.

The experimental dependence of the amplification coefficient η on the field H for a fixed klystron frequency is a typical plot observed in dynamic polarization: the amplification has a maximum negative value η_- at $H_- = H_0 - \frac{1}{2}\Delta H$ (corresponding to a "forbidden" transition with frequency $\nu_e + \nu_{nuc}$) equal to zero when $H = H_0$ (ν_e transition), and has a maximum positive value η_+ at $H_+ = H_0 + \frac{1}{2}\Delta H$ ($\nu_e - \nu_{nuc}$ transition). At 0.55 ± 0.05°K the amplification coefficients were