UPPER LIMIT OF THE CONTENT OF ANTINUCLEI IN PRIMARY COSMIC RAYS

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The question of the symmetry of the world with respect to the content of matter and antimatter in the universe is one of the most interesting questions of modern astrophysics.

Estimates of the upper limit of the content of antinuclei ($Z \geq 3$) in cosmic rays were obtained in several emulsion investigations [1 - 4] with balloons [1, 2] and satellites [3, 4]. In two other investigations [5, 6], a different procedure was used to observe antinuclei with $Z = 2$ [5] and $Z \geq 6$ [6].

The antinuclei were sought in the emulsion among the stopped multiply-charged particles. We have previously [4] considered the corrections that must be introduced when determining the upper limit of antinuclei if account is taken of the difference between the interaction cross sections of nuclei and antinuclei in emulsion.

We therefore considered the deceleration and interaction of ordinary nuclei in the emulsion and the deceleration and interaction of antinuclei with allowance for annihilation in flight. It was shown as a result that at equal energy and charge distributions of the nuclei and antinuclei entering the emulsion stack (of depth 10 cm), the number of stopped antinuclei will be approximately half (0.48) the number of ordinary multiply-charged particles. This coefficient must be taken into account when determining the upper limit of the content of the antinuclei. In [4], we obtained $N_{\tilde{A}}/N_a < 0.59\%$ by investigating the stopped primary nuclei registered in an emulsion irradiated on the satellite "Kosmos-4" with allowance for all the necessary corrections.

At the present time, using data on the number of stopped multiply-charged particles ($Z \geq 3$) registered in our other investigations with emulsions irradiated on satellites ("Kosmos-213" and "Soyuz-5") and automatic interplanetary stations ("Zond-5" and "Zond-7"), this upper limit can be decreased by one order of magnitude. A total of 2750 multiply-charged nuclei stopped in the emulsion were registered[1]. Taking into account the aforementioned corrections, we obtain a value $N_{\tilde{A}}/N_A < 0.07\%$ for the upper limit of the antinuclei. This limit can be decreased even more by combining our data with the number of heavy nuclei stopped in emulsion registered by others [1 - 3]. These combined data, with allowance for the corrections, yield $N_{\tilde{A}}/N_A < 0.05\%$, i.e., the number of antinuclei in the vicinity of the earth and of the moon is in any case less than 5×10^{-4} of the multiply-charged component of ordinary nuclei.

The determination of the upper limit of the content of antiparticles in primary cosmic radiation was the subject of a paper [5] delivered at the Australian International Conference on Cosmic Rays (August, 1971). Its authors used a permanent magnet (5.5 kG) in conjunction with spark and scintillation counters. The apparatus was irradiated on balloons for 43.5 hours at an average residual-atmosphere pressure 3.9 g/cm^2. The obtained upper limit of the anti-α-particle content was $N_{\tilde{\alpha}}/N_{\alpha} < 0.24\%$ in the energy interval 0.3 - 3 GeV/nucleon.

Searches for antinuclei ($Z \geq 6$) at high energies, $5.0 \leq E \leq 9$ GeV/nucleon, were carried out in [6]. The authors used at low latitudes the features of

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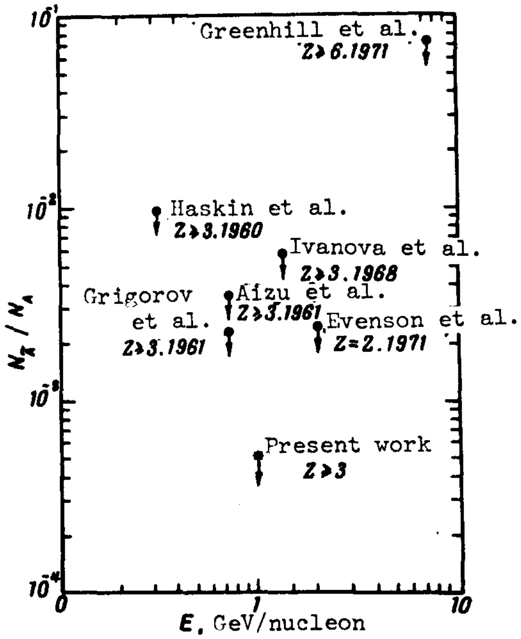
[1] The nuclei stopped in our stacks had energies in the region $E \leq 1$ GeV/nucleon.

the geomagnetic hardness cutoff of positive and negative particles traveling in a definite direction. The detector was a telescope of scintillation counters in conjunction with a gas Cerenkov counter. The value obtained was $N_{\tilde{A}}/N_A < 7.5\%$.

Data on the upper limit of the content of antinuclei in cosmic rays, obtained by different workers, are gathered in the figure. The points obtained by the emulsion method pertain to the upper limit of the investigated energy interval, while the results of [5, 6] pertain to the mean-weighted energy value. We note that a correction for the difference in the interaction cross sections of the nuclei and antinuclei in emulsion was made only in our earlier paper [4] and in the present paper. Introduction of such a correction into the data of [1 - 3] should improve the obtained upper limit by an approximate factor of 2 (for an emulsion depth ~10 cm).

From the data shown in the figure it is seen that the accuracy with which the upper limit of antinuclei is determined in the present paper greatly exceeds all the earlier ones.



Data on the upper limit of the relative content of antinuclei in primary cosmic rays, obtained by different workers.

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INFLUENCE OF "PARASITIC" GENERATION WITH WAVELENGTH 3.39 μ ON THE RADIATION FLUCTUATIONS OF AN Ne-He LASER OPERATING IN THE 0.63 μ REGION

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Of the two neon lasing transitions $3s_2 - 2p_4$ ($\lambda = 3.39$ μ) and $3s_2 - 3p_4$ ($\lambda = 0.63$ μ), which are connected by a common upper level, the former has a much larger gain and saturation parameter. One can therefore expect lasing at 3.39 μ to decrease the sensitivity of a 0.63 μ Ne-He laser to pump fluctuations. To estimate this effect quantitatively, a laser was constructed consisting of a discharge cell C filled with a Ne^{20} - He^3 mixture and a compound resonator made up of mirrors M_1, M_2, and M_3 (Fig. 1). The mirror M_2 had maximum reflectance at $\lambda = 0.63$ μ, M_3 at $\lambda = 3.39$ μ, and mirror M_1 reflected both wavelengths