PROTON COMPONENT OF COSMIC RADIATION AT SEA LEVEL

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Submitted to JETP editor May 21, 1957

J. Exptl. Theoret. Phys. (U.S.S.R.) 33, 542-544 (August, 1957)

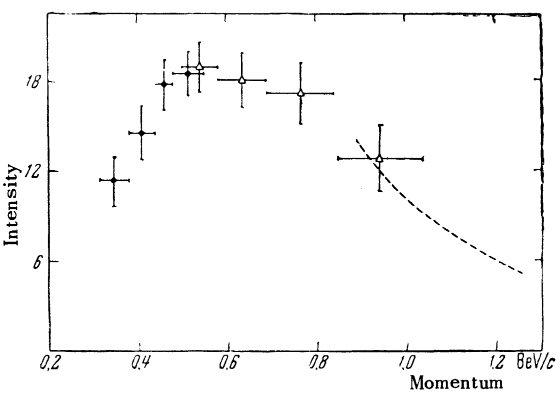
MANY studies[1-13] have been carried out on the proton component of cosmic rays at sea level for momenta greater than 0.5 — 0.6 Bev/c. The proton component of the soft radiation has been investigated at sea level only by Filthuth,[14] who considered momenta in the interval 0.2 — 0.9 Bev/c. For momenta greater than 0.6 Bev/c, his results differ from those of many other authors by factors of 1.5 — 2. As has been pointed out by Ogilvie,[10] this indicates a systematic error in Filthuth's measurements. One can suppose, furthermore, that his results are not reliable in the low momentum range which has not been investigated by others.

Up to the present time, the lack of adequate and reliable data on the soft proton component of cosmic rays at sea level has been the main obstacle to finding the position of the maximum in the spectrum, and to obtaining the total intensity of the vertical proton current at sea level. The purpose of the work now being reported is to fill in this gap.

The experimental method has been described in detail previously.[12] The measurements lasted 2458 hours. The absolute value of the vertical proton current was measured relative to those particles of the hard component which had ranges greater than 15 cm. Pb. The current of the latter was taken to be 0.785 $\times 10^{-2}\,cm^{-2}\,sec^{-1}\,sterad^{-1}$, in accordance with the value adopted earlier.[12]

Momentum interval Bev/c	0.31—0.38	0.38—0.44	0.44—0.48	0.48—0.55
Intensity [$cm^{-2}\,sec^{-1}\,sterad^{-1}\,(Mev/c)^{-1} \times 10^{-8}$]	11.5±1.6	14.5±1.8	17.8±1.6	18.4±1.5

The results of our measurements in various proton momentum ranges from 0.31 to 0.55 Bev/c are shown in the table to the left. These results are plotted in the figure, together with the results obtained previously[12] for momenta from 0.5 to 1.04 Bev/c. It is clear that neighboring points from the present and from the previous sets of data fit together well. The dotted curve is $(1.0 \times 10^{-7})\,p^{-2.8}$, and represents the results of other authors[4,13] in the momentum region $p > 1$ Bev/c, which we have not investigated. The figure shows that near 0.9 Bev/c, our data agree well with this curve.



Proton spectrum at sea level. Δ — from Ref. 12; - - - from Refs. 4 and 13; ● — data from the present measurements.

For momenta between 0.3 and 0.6 Bev/c, Filthuth's data[14] are 1.5 — 2 times smaller than ours. As mentioned above, a similar discrepancy between Filthuth's data and the data of other authors exists for larger momenta. Our measurements thus support the supposition that there is a systematic error in Filthuth's measurements.

Integrating our spectrum between 0.37 and 1.04 Bev/c, we find that the total intensity of the vertical proton current at sea level in this momentum interval is $I_1 = (1.12 \pm 0.03) \times 10^{-4}\,cm^{-2}\,sec^{-1}\,sterad^{-1}$. We had used the same method and apparatus earlier[15] to investigate the proton spectrum on Alagez mountain 3250 m. above sea level. The intensity of the proton component in the same momentum interval was then $I_2 = (12.15 \pm 0.30) \times 10^{-4}\,cm^{-2}\,sec^{-1}\,sterad^{-1}$. From the ratio of the two, $I_2/I_1 = (10.84 \pm 0.40)$, we can calculate the mean absorption length, which had previously been obtained by various workers using different methods. We obtain $L = (143.5 \pm 6.1)\,g/cm^2$, which agrees well with the value $L = (140 \pm 10)\,g/cm^2$ obtained by Mylroi and Wilson,[4] who measured the intensity of the proton component at three heights.

In order to find the total vertical proton current at sea level, we extrapolate the curve shown in the figure to the origin, and use the results of other authors[4,13] for momenta greater than 1 Bev/c. We then find that the total intensity is $I = (1.88 \pm 0.05) \times 10^{-4} \text{cm}^{-2} \text{sec}^{-1} \text{sterad}^{-1}$, which is 2.4% of the number of particles which will penetrate 15 cm Pb.

The maximum of the proton spectrum at sea level is at 0.5 — 0.6 Bev/c. The maximum in the proton spectrum at 3250 m. above sea level is at about the same place.[15] The shapes of the two spectra are the same within experimental error, which is to be expected since for the momenta considered both are the spectra of secondary particles. The shape of the spectrum and the position of the maximum agree well with the theoretical spectrum for secondary protons as computed by Rossi.[16]

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Translated by R. Krotkov
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CYCLOTRON RESONANCE IN PLASMA

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Submitted to JETP editor May 21, 1957

J. Exptl. Theoret. Phys. (U.S.S.R.) **33**, 544-546 (August, 1957)

THE physical mechanism of cyclotron resonance in metals, for which a theory was formulated in Refs. 1 and 2 leads to the belief that a similar effect should occur in a compensated electron-ion plasma. Let us recall that cyclotron resonance in metals occurs only in a direct magnetic field H parallel to the metal surface* when an electron is repeatedly returned under the influence of the magnetic field at the necessary phase to a skin layer whose thickness δ is small compared with the radius of the electron orbit r in the magnetic field. Naturally, a sufficiently large number of revolutions must be performed in the length of the free path ℓ before resonance can be observed, i.e., $\ell \gg 2\pi r$. Otherwise, resonance is generally absent. Cyclotron resonance occurs when the external field frequency ω is a multiple of the Larmor frequency $\Omega = eH/mc$.

Let us consider the conditions under which resonance in plasma is possible (we neglect ion motion). It is necessary for resonance that "anomalous skin effect" occur:[1,2]

*Cyclotron resonance was recently observed in tin and bismuth.[3]