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Primary Flux of High Energy Protons and α -Particles

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Measurements utilizing the emulsion cloud chamber technique described in the previous letter have been used to obtain flux values in the 10^{12} - 10^{13} ev region.

70 cm² of emulsion halfway down in the "cloud chamber" were systematically scanned for all showers crossing the emulsion; a total of fifty-six such showers were found. Many of these showers could only be followed for a short distance and then became too diffuse to follow further. These showers must have come largely from low energy interactions of the order of 10^{11} ev. (Showers with a γ -ray in excess of 3×10^{11} ev can be followed through the entire stack.)

To obtain flux values it was necessary to eliminate those showers which were detected with a low and unknown efficiency. The condition was imposed that all showers must contain at least one secondary electron shower with an energy greater than 3×10^{11} ev. This left a total of fourteen showers. Detailed examination of these events showed that six were γ -ray induced and eight caused by nuclear interactions. The median energy of these eight events estimated from kinematic considerations was 4.5×10^{12} ev. (We can arrive at an independent estimate from our requirement of one secondary electron shower whose energy is in excess of 3×10^{11} ev; we infer from this median energy of $\sim 3 \times 10^{12}$ ev.) In all these eight cases the primary had a charge $Z \neq 1$.

Using an absorption mean free path for nucleons in air of 100 gm/cm² and a geometric interaction mean free path in the stack, we evaluate the integral primary flux with energy greater than 4.5×10^{12} ev as .04 particles per meter²

per ster per sec at the top of the atmosphere assuming an isotropic flux. On the assumption of a power law for the integral primary spectrum we find an exponent of $1.45 \pm .15$ using the known values at low energies.¹ The error takes into account the uncertainty of the median energy which we consider to be of the order of 2.

In a less systematic survey of an additional 70 cm² we have found two α -particle induced showers with energies per nucleon in the same range as the proton induced showers. It therefore appears that α -particles constitute about 10% of the primary flux and that accordingly the ratio of α -particles to protons remains relatively constant over a large energy range. This seems to be in agreement with results previously reported² which indicate a similar velocity spectrum for all components of the primary beam and is not in agreement with the predictions of the simple Fermi³ theory of acceleration of cosmic ray primaries.

References

* Supported by A.E.C.

- 1 Winokler et al, Phys. Rev. 79, 656 (1950).
- 2 Kaplan et al, Phys. Rev., in press.
- 3 E. Fermi, Phys. Rev. 75, 1169 (1949). The Fermi theory predicts an exponent for the power law which is inversely proportional to the mean free path.