The true primary spectra for protons and alpha particles are represented by the Churchill data, and if the alpha-particle data are multiplied by a factor of 6.7 to adequately normalize them to the protons in the rigidity range from 1.5-20 BV, a distinct splitting of the two spectra is noted at low rigidities (Fig. 4). Both spectra are falling sharply at the lowest rigidities we can measure, however.

Our results are in good agreement with those obtained by emulsion techniques used on a companion flight and reported in an accompanying Letter.[8]

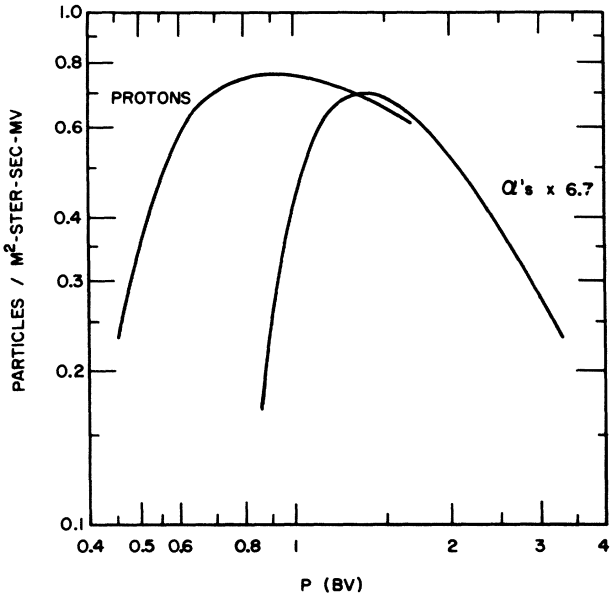

FIG. 4. Comparison of low-energy proton and alpha-particle spectra on a rigidity basis (Churchill data). Differential alpha-particle intensities multiplied by 6.7 to normalize with high-energy proton data in range 2-20 BV. P is the particle rigidity defined as momentum/unit charge and expressed in units of BV.

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HYDROGEN AND HELIUM NUCLEI IN THE COSMIC RADIATION

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In the past few years, the low-energy proton component of the primary cosmic radiation has been measured in a number of separate experiments.[1-3] The results of these experiments have not been in complete agreement, and although some of the discrepancies have almost certainly been due to temporal variations, it seems highly likely that experimental effects have also been present. Among the most interesting questions that can be sutdied in these experiments is whether the constant value of approximately 7.0 for the ratio of protons to α particles at a given rigidity, known to hold at rigidities above 2.0 BV, still holds at lower rigidities. The observation of a variation in this ratio has important consequences in any theory of the modulation or propagation of cosmic-ray particles in the solar system.[3]

For these reasons a new investigation has been made of the low-energy protons and α particles in the primary radiation, using a nuclear emulsion detector with limited temporal resolution. In this detector a stack of nuclear emulsions was mounted in a device which rearranged the orientation of the emulsions at a preset time. This device will be described elsewhere.[4] This detector was flown on a high-altitude research balloon launched from Fort Churchill on 28 July 1963 at a time when the Deep River neutron monitor bihourly counting rate was 2008. The moving device was activated when $\sim$3 g/cm^2 of residual atmosphere lay above the balloon, which then floated under a mean amount of matter of $\sim$2 g/cm^2 for 11 hours. As a result of the use of the emulsion mover,[4] no correction had to be made for particles entering during the balloon ascent, while due to the great altitude of the flight, $\sim$149 000 feet, the correction for particles produced in the overlying atmosphere was reduced to a minimum. Unlike other detectors, nuclear emulsions permit advantage to be taken of the self-screening feature of a layer of overlying material which registers the passage or generation of particles. As a consequence, the copious low-energy secondary particles can be eliminated, and the correction for secondary particles becomes relatively minor.

The processed nuclear emulsions have been examined for protons and α particles with rigidities between those imposed by the overlying material, 0.38 BV and 0.70 BV, respectively, and those presently set by experimental limitations of 1.1 BV and 4.0 BV.[5] Details of the procedures used will be published elsewhere, but they represent standard techniques, similar to ones frequently employed previously in nuclear emulsion experiments.

The differential rigidity spectra at the top of the atmosphere obtained from this experiment are shown in Fig. 1 with the helium nuclei multiplied by a factor of seven to normalize them to the higher rigidity protons. It can be seen from this figure that there is a definite and distinct splitting of the proton and α-particle spectra but that, like the α particles, the proton intensity starts to fall sharply below some characteristic rigidity. These results are in very good agreement with those obtained from a recent counter experiment described in an accompanying Letter[6] nor do they conflict with the upper limit to the proton intensity recently reported by Brunstein.[7]

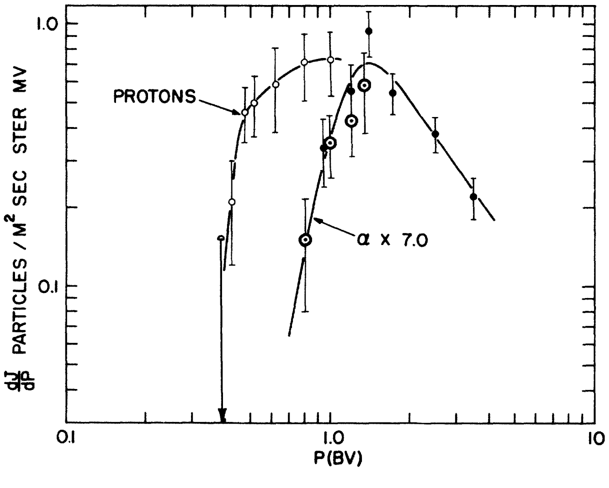

FIG. 1. The differential rigidity spectra of protons and α particles: the differential intensity, dJ/dP, in particles/m^2 sr sec MV, as a function of the rigidity P in BV. Protons are shown by the open circles, while the α particles, which are multiplied by a factor of 7.0, are shown by the open circles with dots or closed circles depending on experimental conditions.

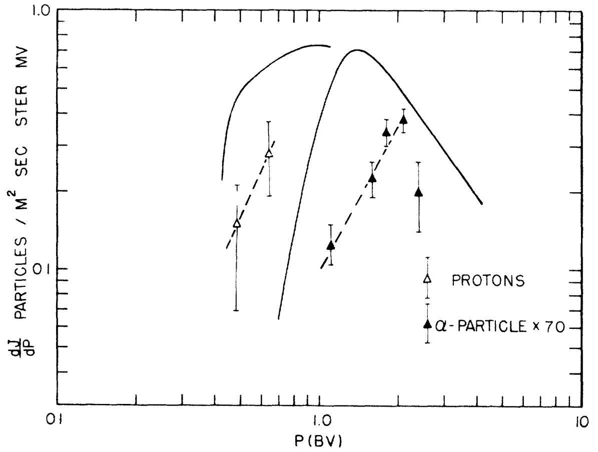

FIG. 2. The solid curves obtained in Fig. 1 compared with the differential rigidity proton and α-particle data measured in 1961 (reference 3).

Figure 2 compares the results of this experiment with those obtained from an emulsion detector flown in 1961,[3] and shows that there has been a definite increase in intensity of both components which is presumably associated with the decline in solar activity from 1961 and 1963. This result appears to be in contradiction with the decrease in intensity observed by Meyer and Vogt,[1] using counter detectors, between 1960 and 1961.

An examination of the preliminary, unpublished data from the IMP satellite on the low-rigidity protons[8] and α particles[9] suggests that they are in good agreement with an extrapolation of the present data to lower rigidities.

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