Apparent Absence of Low-Energy Primary Cosmic Radiation

THE form of the energy spectrum of primary cosmic rays is still uncertain at the low-energy end. The work of Carmichael and Dymond[1] and of Bowen, Millikan and Neher[2] suggested that there was a lower limit at about 2,000 MeV., but this has not been confirmed by Pomerantz[3], who has come to the conclusion that the spectrum continues down to low energies. The matter is of importance owing to its cosmological implications. If the existence of a cut-off in the spectrum be established, some mechanism must be found either for removing the slower particles as they travel through space, or for their initial acceleration with a sharp low-energy limit. The suggestion of Jánossy that a solar magnetic dipole field might be responsible is not now supported by the astronomical evidence.

In a recent communication, Van Allen and Singer[4] have reaffirmed the existence of a lower limit in the energy spectrum, placing it at about 500 MeV. They have compared the vertical intensity of the radiation above the atmosphere, as measured in rockets at geomagnetic latitude 58°, with that determined by Pomerantz in balloon flights at 69°. The equality of the two intensities thus found leads to the conclusion that there are no primary protons in the range 130–560 MeV. It is reasonable to assume also that there are no protons below 130 MeV.

Some doubt must always arise about results drawn from comparisons of absolute intensities measured by different counter systems, owing to the difficulty of determining accurately the absolute flux from the observed counting rates and counter dimensions. But Pomerantz and McClure[5] have recently published some observations made with identical counter telescopes at 52° and 69°, so that the difficulty of comparison does not arise. They find that the hard component increases by a factor of about 1·4 near the top of the atmosphere between these two latitudes. This observation can be interpreted as showing a sharp cut-off in the energy spectrum. This spectrum has been reasonably well established in the region of higher energies by measurements at lower latitudes[6]. Using this and assuming the usual $\cos^4 \lambda$ relation between minimum particle momentum in the vertical direction and geomagnetic latitude λ, we can calculate the expected latitude farther north. We find that the intensity should rise by a factor 1·35 between 52° and 56°. As this is close to the factor found by Pomerantz and McClure between 52° and 69°, we conclude that the intensity must remain constant above about 56°, in approximate agreement with the statement of Van Allen and Singer. The argument is unaffected by the fact that Pomerantz and McClure have made their measurements on the hard component only, as the minimum proton energy required to penetrate the 7·5 cm. of lead absorber in their counter telescope is 260 MeV., which is well below the cut-off energy of the primary spectrum which their observations reveal.

The precise energy at which cut-off occurs must await more extended observations, particularly in the interesting region between 50° and 60°. One difficulty in fixing this energy-limit arises from the geomagnetic field itself. It is usual to calculate geomagnetic latitudes from geographical position by assuming that the field is that of a centred dipole, with axis pole at 78·5° N., 69° W. That this assumption is insufficiently accurate is shown by the existence of the longitude effect. A better approximation is given by an eccentric dipole, with axis cutting the earth's surface at 80·1° N., 82·7° W. For some stations the difference in geomagnetic latitude is not trivial, so the cut-off momentum, which varies as the fourth power of λ, is quite sensitive to the assumed position of the pole. For Edinburgh, for example, the minimum proton energy is 460 or 730 MeV., depending on the approximation used. A further element of doubt is introduced by our ignorance of how the dipole field behaves in relation to the known secular magnetic variations. It has been calculated only for the epoch 1922. More exact information on the terrestrial dipole field is required before cosmic ray data on energy limits can be accurately interpreted.

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Cross-polarization of the Radar Melting-Band

WHEN plane-polarized radiation is scattered by meteorological precipitation particles other than spheres, a component of the back-scattered energy is polarized at right-angles to the plane of polarization of the incident wave. This component will be referred to as the 'cross-polarized' component in this communication. Recent observations at Cambridge and Malvern have shown that the melting particles found just below the freezing-level, which give rise to the well-known radar 'melting-band'[1], produce back-scattered radiation with a greater cross-polarized component than that given by the rain below and the snow above the freezing-level. These observations have been made using separate aerials for transmission and reception, by comparing the echo received when the aerials have their planes of polarization parallel with that received when the plane of polarization for reception is at right-angles to that for transmission.

A wave-length of 3·2 cm. was used at the Cavendish Laboratory and a wave-length in the 8-mm. band was used at the Telecommunications Research Establishment, Malvern. Let I_1 denote the echo intensity measured with parallel planes of polarization and I_2 that measured with crossed planes of polarization; then Table 1 summarizes values of the ratio I_1/I_2 measured on several occasions at the two wave-lengths. Measurements were made of the intensity not only of the melting band echo, but also of the echoes from the rain below the freezing-level and the snow above.

Table 1. RATIOS OF THE INTENSITIES OF THE MAIN COMPONENT TO THE CROSS-POLARIZED COMPONENT

Wave-length (cm.)	I_1/I_2		
	Rain	Melting region	Snow
0·8	15±1 db.	7±1 db.	12±2 db.
3·2	21·8±0·4 db.	16·9±0·3 db.	19·9±0·6 db.