Energy Spectrum of Particles Bombarding the Earth

INTERSTELLAR matter may be captured by the gravitational field of the Sun. Harrower[1] suggests that this matter is intercepted by the Earth's atmosphere at the 400-km. level, giving rise to radio-star scintillation. He estimates[1] the flux of hydrogen atoms or nuclei of about 10 eV. as of order 10^{13} cm.$^{-2}$ sec.$^{-1}$.

Balmer emissions with Doppler shifts corresponding to proton velocities of order 1,000 km./sec. (energy 10^4 eV.) have been observed in auroral displays. The flux of protons has been estimated[2] as of order 10^7–10^8 cm.$^{-2}$ sec.$^{-1}$. Protons coming from outside the Earth's atmosphere and penetrating to auroral depths must have incident energies of order 10^5 eV. Very little is known about when and where auroral protons reach the Earth.

In the energy region above 10^9 eV., cosmic rays follow an integral energy (E) spectrum given[3] by $N\ (>E) \propto E^{-1 \cdot 5}$. The exponent may increase for $E > 10^{16}$ eV.

The cosmic-ray integral energy spectrum is plotted as a solid line in Fig. 1. The estimated fluxes of interstellar and auroral particles appear to fit the straight-line portion of this spectrum extrapolated to lower energies.

This fit could not be predicted *a priori*, and according to present theories it must be fortuitous or based on inaccurate estimates. Clearly, it is important to examine the intermediate energy intervals.

As shown in Fig. 1, the cosmic-ray spectrum appears to be cut-off at an energy of about 10^8 eV. However, it is known that the flux of particles in this energy region varies greatly with solar activity[4]. It may be supposed, then, that this cut-off is due to some solar influence[3].

The geomagnetic field and the shielding nature of the atmosphere also influence measurements in the energy-range about 10^5–10^8 eV. However, Winckler *et al.*[5] have found a possible association between cosmic radiation and auroral activity. Also Van Allen and others[6] measured the flux of soft radiation at rocket altitudes as much greater at the northern auroral zone than elsewhere.

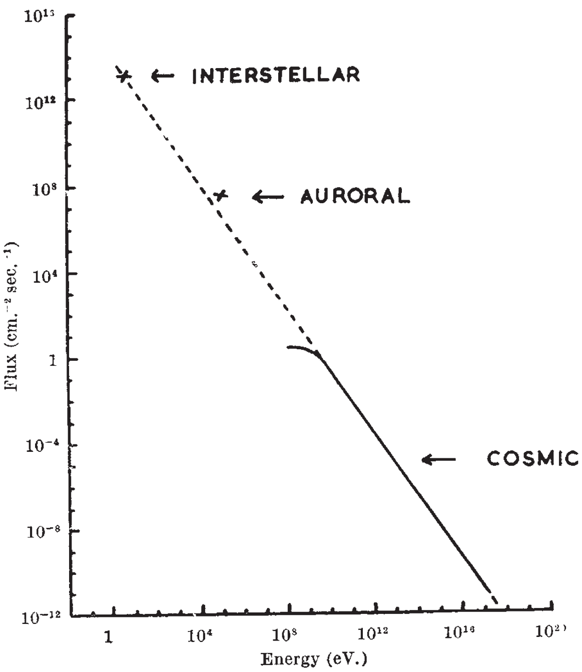

Fig. 1. The integral energy spectrum of particles entering the Earth's atmosphere. The cosmic-ray spectrum is shown as a solid line

Recent measurements using artificial Earth satellites have indicated that the flux of ionizing radiation at an altitude of 1,000 km. is about one thousand times the flux at 100 km. This might be interpreted as further evidence for a continuation of the energy spectrum between 10^6 and 10^8 eV.

The energy-range around 10^5 eV. could be studied by examining height-intensity distributions of auroral Balmer emissions. No accurate measurements are available, and the point plotted in Fig. 1 represents the integral flux estimated by several workers[2]. Chamberlain has found[2] that an integral energy spectrum of $E^{-1/2}$ may govern the auroral protons. However, the uncertainties in this estimate are considerable.

To my knowledge, no quantitative measurements in the energy-range between 10 and 10^5 eV. have been reported.

Since first considering the data presented in Fig. 1, I have seen a recent paper by Parker[7]. He has shown that the cosmic-ray gas can be effectively coupled to motions of ordinary matter, and that this represents a state of general dynamic balance. This treatment suggests that the relation noted in Fig. 1 may not be fortuitous. Clearly, much more theoretical and experimental study of the problem is essential.

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Coherent Scattering of 1·33 MeV. γ-Rays by Lead

THE cross-section for coherent (elastic) scattering of γ-rays from a heavy atom is expected to include a contribution from Delbrück scattering, the scattering of light by a static electric field[1]. This contribution should appear as a deviation of the experimental cross-section from the cross-section calculated taking only Rayleigh scattering and nuclear Thomson scattering into account; but uncertainties in both theory and experiment have made it difficult to draw any definite conclusions from the results at low energies[2,3].

We have measured the differential cross-section for elastic scattering of 1·33 MeV. γ-rays from lead using a larger γ-ray source than previous workers[2], and using a different method[4] of examining the scattered γ-ray spectrum. In this method a scintillating crystal is viewed by two photomultipliers 1 and 2, the spectrum of 'gated' pulses from 1 being recorded: thus a pulse from 1 is recorded if it coin-

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