LETTERS TO THE EDITORS

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Rate of Accretion of Cosmic Dust on the Earth

As guest professor of geophysics at the University of Hawaii, I have had opportunities for collecting cosmic dust by filtering large volumes of air through fine-pored filters at Mauna Loa Observatory on Hawaii (11,000 ft.) and from the summit of Mt. Haleakala on Maui (10,000 ft.), localities where the air is generally free from terrestrial dust to a remarkable degree. The filters were analysed for the radioactive fall-out products, strontium-89 and strontium-90, in the laboratories of the U.S. Atomic Energy Commission in New York, and for iron, nickel and cobalt in the II Chemisches Institut der Universität, Vienna. I am indebted to Mr. John H. Harley for the strontium analyses, which will be published elsewhere, and also to Prof. F. Hecht and his collaborator Dr. E. Tomic of Vienna for carrying out the analyses for the ferrides.

Of the twenty-two filters from Mt. Haleakala so far analysed for ferrides, all contained notable quantities of nickel, whereas in seven of the nine filters from Mauna Loa nickel was also found, far in excess of any possible contamination from terrestrial sources. The average weight of nickel per 1,000 m.^{3} of air passed through the filters was 14·3 μgm. as compared with 1,577 μgm. of iron, that is, a nickel to iron ratio of 0·9 per cent. Cobalt was also found in several of the filters, although in much smaller quantities than nickel, the ratio of cobalt to iron being 0·2 per cent.

The weight of cosmic dust on the filters may be estimated from the nickel content using the average amount (2·5 per cent) of nickel in meteorites of all kinds quoted by F. G. Watson[1], which gives a weight of meteoric dust of 572 μgm./1,000 m.^{3} of air.

Assuming the dust-content of cosmic origin in the atmosphere to be uniform up to the 100-km. level, for the whole atmosphere below that level a quantity of suspended dust of cosmic origin of 28·6 million tons is obtained.

In order to find from this figure a value for the annual increment of cosmic dust to the Earth, we have to assume a probable rate of descent from the 100-km. level to the 3-km. level, where the dust was collected. In the case of the finest volcanic dust from the Krakatoa eruption in 1883, according to W. J. Humphreys[2], it required about two years to settle down to the Earth's surface. With a similar rate of descent, the cosmic dust suspended in the atmosphere should be renewed in the course of two years, which makes the annual increment of such dust to the Earth equal to one half the figure given above, or 14·3 million metric tons. If more rapid renewal of the cosmic dust suspended in the atmosphere is assumed, the annual increment becomes correspondingly higher.

Comparing this figure with Van de Hulst's value[3] for the weight of the interplanetary dust giving rise to the zodiacal light and being swept up by the Earth, as 1,700 tons a day, one obtains a rate of accretion for interplanetary dust to the Earth of only a little more than 4 per cent of that for meteoric dust, or 0·62 million tons a year.

On the other hand, Watson assumes the total weight of meteoric matter reaching the Earth to be "between 1,000 or, perhaps, 10,000 tons per diem" (ref. 1, p. 94). Even with the higher of these two estimates, one finds that a total weight of 3,650,000 tons of meteoric matter should reach the Earth annually, or about one-fourth of that estimated from these experiments.

Considering the general interest for many different branches of geophysics of the rate of accretion of cosmic dust, these discrepancies call for repeated and extended experiments of this kind at other high-altitude observation posts.

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[1] Fletcher, G. Watson, "Between the Planets", 179, 2nd edit. (Harvard Univ. Press, 1956).
[2] Humphrey, W. J., "Physics of the Air", 576 (1920).
[3] Van de Hulst, *Astrophys. J.*, **105**, 485 (1947).

Energy Spectrum of Cosmic Radiation

THE spectrum of cosmic radiation has the remarkable property that it is a power function

$$f = \text{const. } p^{-n} \quad (1)$$

(where p is momentum), in which n has a constant value of about 2·5 for several powers of ten of p. In Fermi's theory, n is given by the ratio τ/T between the time of acceleration τ and the time of absorption (or diffusion) T. This means that the empirical formula is obtained only if one assumes that accidentally τ and T are of the same order of magnitude, and that the ratio is constant over a very wide range of momentum. Neither of these assumptions is plausible.

It is the purpose of this communication to point out that a power law can be obtained if we assume that particles, which are injected at low energies, are pumped up to higher energies by a pump, the speed of which is a power function of the momentum. No considerable loss of particles should occur during the acceleration, but when the particles have reached the maximum energy which can be stored in the accelerator, they leave the accelerator. (In this way the time of dissipation is determined by the time of acceleration.) Hence all cosmic-ray particles move up through the energy spectrum in a more or less systematic way, and the time they spend in a certain energy-range is inversely proportional to the speed of the pump.

This effect can be produced in several ways, and we shall consider a mechanism in which the betatron effect is combined with a scattering or diffusion of the particles[1]. If the magnetic field H in a certain volume U' increases, the momentum p of charged particles in the volume increases by Δp, which is proportional to p. If the particles are scattered, or diffused out of U' to an adjacent volume where H is constant, and later the field in U' returns to its initial value, the net result of the process is that a number of particles fU' have increased their momenta by

$$\Delta p = \alpha p \quad (2)$$

where α is a constant. If the process is iterated and low-energy particles are injected at a constant rate, this leads to a power spectrum with $n = 1$.

If this process takes place in the neighbourhood of the Sun under influence of varying magnetic fields