(5) Three main kinds of collisions occur: protons (mass 1), C, N, O (12 to 16); Br, Ag (80 to 108). The last kind gives rise to forks with the two branches at nearly right angles and equally ionizing. Small bumps along the fission tracks are probably owing mostly to the second kind, as well as the occasional blooming near the end. About 30 recoil protons have been seen. When the range and angle of deflection of the proton are suitable for measurement, the velocity of the fragment can be derived at the point of collision. As the group to which the fragment belongs is evident, the writer intends to obtain independent range-velocity curves for each group of fragments.

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The Density Spectrum and the Origin of Extensive Atmospheric Cosmic-Ray Showers

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RECENTLY Wolfenstein[1] calculated the density spectrum of extensive cosmic-ray showers (relation between frequency and density of the showers) at various altitudes on the basis of the multiplicative cascade theory of electrons and photons. He compared his results with the density spectra deduced from the measurements with ionization chambers of Lewis[2] and others.[3] Wolfenstein concluded that the extensive showers were not generated by cascade multiplication of very energetic primary electrons because the experimental frequencies are more than ten times greater than the theoretical, and also because the character of the theoretical and experimental spectra are quite different.

The same problem was studied by the writer and coworkers during 1942, 1943, and 1944. The theoretical calculation of the density spectra at various altitudes was carried out[4] by employing Heisenberg's and Molière's equations for cascade multiplication.[5] Our results are in good agreement with Wolfenstein's which indicates the equivalence of the approximations introduced in the calculations of various authors. The experimental spectra were determined at sea level and at 2200 m with coincident counters.[6] The agreement between theory and experiment was excellent, the character of the spectra is the same, and the experimental frequencies exceed the theoretical by a factor of about 1.7 which is within the uncertainty of the calculations. We therefore conclude in contradiction to Wolfenstein that the cascade theory explains quite satisfactorily the origin of extensive showers.

The reason for the disagreement between Wolfenstein's conclusion and ours lies in the diversity of the experimental data with which the theory is compared, a diversity which we believe is caused by the different experimental methods employed to measure the density of showers. We think our data on the density obtained from the measurements are more reliable than those used by Wolfenstein because with the ionization chamber the total ionization is recorded, hence the deduced densities may be influenced by secondary radiations of all types (multiplicative electrons, nuclear fragments, etc.) generated in the walls of the chamber. The counter-measurements obviously are not invalidated by such local phenomena because G.M. counters record the "events" and not the related secondary processes.

In support of our thesis we draw attention to the circumstance that other counter data may be well explained by the cascade theory. This is the case for the frequency-height measurements of Hilberry[7] and the frequency-shower measurements of Auger (see Molière[5]). On the contrary, the frequency-burst size measurements of Lewis with the ionization chamber, as was also pointed out by Wolfenstein, do not agree with the theory.

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A Note on the Proton Hypothesis of the Primary Component of Cosmic Rays

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FROM the results of Schein and collaborators[1] it has been concluded[2] that the primary component of cosmic rays may consist exclusively of protons. We want to point out, firstly, that this conclusion is not yet certain, because at the maximum altitude used by Schein and his collaborators, *viz.* 2 cm Hg, the total radiation, soft and hard, still contains about 50 percent electrons, as is shown by a comparison between the curves of Pfotzer and of Schein.[1] Whether or not these curves coincide at the top of the atmosphere cannot be decided, however, by extrapolation from the experiments of Schein *et al.*, but only from the results of the V-2 rocket flights. Apart from this, in order to compare the two curves safely they must be measured with the same apparatus and at the same place. In order to obtain information on the energies of the large number of electrons certainly present up to the highest altitudes investigated in balloon flights, it would also be extremely important to obtain the transition between the Schein and the Pfotzer curve, i.e., to measure the intensity *vs.* altitude curve for lead absorbers with thickness *between* 0 and 4 cm, and not only for lead absorbers *above* 4 cm. (We also note that the 4-cm and 6-cm absorbers are only represented by *one* point each on the Schein curve, *viz.*, at the maximum altitude.)

Next we want to remark that the proton hypothesis of the primary cosmic rays leads to difficulties in the interpretation of other experiments. First of all, it would give a high positive east-west asymmetry at the top of the atmosphere for *both* the hard and the soft component (and thus for the total). Experimentally Johnson and Barry[3] found, however, for the *total* radiation averaged over altitudes from 3–10 cm Hg only an east-west asymmetry of +7 percent (at geomagnetic latitude 20°N and for zenith angle 60°). It is to be hoped that this very important result will be checked in further experiments. The author has previously suggested[4] that this small east-west asymmetry of the *total* radiation at high altitudes may perhaps be interpreted as being the result of the combination of a high *positive* east-west asymmetry for the hard component, assumed to be produced mainly from primary positive protons, and a high *negative* east-west asymmetry for the soft component, assumed to be produced mainly from primary *negative* protons. Direct measurements at high altitudes of the east-west asymmetry of the soft and hard components *separately* are, therefore, highly desirable.

Apart from the problem of the east-west asymmetry it is also very difficult to interpret from the proton hypothesis the conspicuous difference between the latitude effect of the soft and that of the hard component, the first increasing strongly with increasing altitude, reaching values about 70–80 percent at the Pfotzer maximum,[5] the latter increasing only slowly with altitudes from about 12 percent at sea level to about 18 percent at an altitude of 21 cm.[6]

From the earlier hypothesis assuming the soft component to be created by cascade multiplication of primary electrons from the top of the atmosphere and down, the latitude effect could be satisfactorily accounted for, as shown by Heitler,[7] assuming a primary energy spectrum of approximately the well-known inverse power type. If, now, as in the proton hypothesis, the soft component is to be produced not as a secondary, but as a *tertiary* radiation, but still from the same primary energy spectrum and still practically at the top of the atmosphere, as in the form of the proton hypothesis given by Heitler *et al.*[2] (i.e., protons being transformed in single processes into long-lived pseudoscalar and short-lived vector mesons, the latter decaying at once into electrons and neutrinos), energy is lost in the transformation of the primary radiation into the soft component. Consequently the primary energy necessary to produce the same primary electron energies at the top of the atmosphere as before is much higher. As the primary energy spectrum decreases with increasing energies and as the field sensitive region is only 2–15 Bev, this energy decrease means that the latitude effect becomes smaller than that calculated from the earlier electron hypothesis which agreed with experiments. (Unfortunately Heitler and Walsh do not give the intensity *vs.* altitude curves of the soft component at equator and at 50°N, which would follow from their theory.)

In the Feynman-Bethe form of the proton hypothesis,[2] the protons produce in multiple processes only the long-lived pseudoscalar mesons ($\tau \sim 2\times 10^{-6}$ sec.) decaying into electrons and neutrinos all the way down through the atmosphere and not only at the top of the atmosphere as in Heitler's form of the theory. In this form the difference between the latitude effect of the soft and that of the hard component would be even more difficult to interpret than in Heitler's form, partly because the energy decrease in the transformation of the primary radiation into the soft component is here much larger owing to the multiple processes, partly because after a few radiation units the soft component will be in equilibrium with the mesons, as is known from the calculations of Euler and Heisenberg.[8] All through the lower part of the atmosphere the latitude effect of both components should consequently increase approximately in the same way, in contrast to the difference observed.[5,6] Another difficulty for this form of the proton hypothesis is to explain the increase of the ratio of soft to hard intensity in the lower part of the atmosphere. A further consequence is that the electrons of the soft component produced in this way would be expected to be less energetic than those produced in the Heitler theory. Not only the intensity of the soft component but also the electron spectra at different altitudes would, therefore, be interesting to have worked out and compared with the spectra found experimentally.

We thus conclude from the experimental evidence as it stands at present that it seems necessary to assume at least one more component in the primary radiation, in addition to the protons which seem to be the primaries of most of the hard component. Whether this second component consists of electrons, negative protons[4] or perhaps higher charged nuclei as suggested by Swann[9] can, of course, only be decided by further experiments. *Especially a more systematic investigation of the intensity, latitude effect, and east-west asymmetry* of the soft and hard component *separately* at high altitudes is highly desirable.

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On the Possible Use of Brownian Motion for Low Temperature Thermometry

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IN a recent communication,[1] Lawson and Long proposed two interesting methods for low temperature thermometry using spontaneous electrical fluctuations. In the present note it is desired to point out that a drastic modification of the first method would be required, and that a fundamental principle, apparently overlooked, invalidates the conclusions in favor of the second method proposed.

Their first method consists in measuring the thermal voltage fluctuations generated in a resistance of large value at the grid of an amplifier valve. The arrangement suggested is one of an ohmic resistor $R(\sim 10^9\Omega)$ in parallel with inevitable circuit capacity ($\sim 30\mu\mu$f) resulting in a frequency response 0–5 c/sec. Concomitantly, the shot noise in the amplifier valve is assessed by the familiar expression,[2] $3/g$, for a valve operating in the space charge region. This