(c) line 5 of column 2, p. 194, should read
"... to transform Eq. (5) into ..."
(d) line 7 of column 2, p. 194, should read
"with e'/m given by Eq. (8)."
(e) line 14 of column 2, p. 194, omit the word "hence" at the end of the line.
(f) the equation two lines below Eq. (12) is typographically ambiguous and should read

$$\frac{4c}{3}\frac{2I+1}{I}\left(\frac{m_r}{m}\right)^3\left(\frac{\mu_e}{\mu_0}\right)=(15.98053\pm0.00033)\times10^{10}\text{ cm/sec.}$$

Extensive Air Showers and Total Cosmic Radiation

G. Cocconi
Cornell University, Ithaca, New York
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THE experimental evidence that in extensive air showers electrons, photons, mesons, and nucleons are present; i.e., all kinds of particles which have been found in the cosmic radiation present in the lower atmosphere, leads one to support the hypothesis that the event called "extensive air shower," is actually not a special event, but rather the ***unique process*** in which the cosmic radiation present in the lower atmosphere is created.[1] Such an assumption is equivalent to saying that any particle observed in the lower atmosphere is a part of an extensive shower.

This is only apparently in contradiction with the fact that the cosmic radiation observed with ordinary detectors appears to consist of incoherent particles. In fact, two cases are possible:

(a) The observed particle is the only survivor of the extensive shower, at the level where it is detected. In this case, its associated shower particles can be detected only if detectors are located at a higher level, in the direction of the axis of the shower. No experiment of this kind has been performed so far.

(b) The observed particle arrives at the level where it is detected, accompanied by other particles. In this case the other particles can be efficiently detected only if detectors are used whose area S is larger than $\sim1/\Delta$, Δ being the density of the shower in the region where the detectors are located. No apparatus has been so far designed, capable of recording efficiently showers with local densities smaller than about 2 particles per m².

We shall try to estimate what fractions of the various components of the total radiation in the lower atmosphere have been actually observed as particles coherent with other particles, i.e., belonging to extensive showers. Our estimate refers to the altitude of Echo Lake, Colorado (3260 m, average atmos. pressure 708 g/cm²).

At this altitude:

(1) The intensity of the total electronic component of the cosmic radiation coming from the upper hemisphere,[2] is 2.2×10^{-2} cm^{-2} sec.$^{-1}$. This figure includes 1.4×10^{-2} cm^{-2} sec.$^{-1}$ electrons produced by μ-meson decay and knock-on processes. The difference $e=(2.2-1.4)\times10^{-2}=8\times10^{-3}$ cm^{-2} sec.$^{-1}$ is the intensity to be compared with the figure which will be deduced from the data on extensive showers.

(2) The intensity of the μ-meson component[2] is $\mu=2.5\times10^{-2}$ cm^{-2} sec.$^{-1}$.

(3) The data available on the intensity of the N-component are crude estimates made by various authors on the basis of the observed frequencies of nuclear disintegrations. Notwithstanding the large uncertainties involved in the calculations, the results concerning stars and neutron-producing radiation[3] agree in indicating that the intensity of the N-component is about 20 percent of the total ionizing radiation, at the altitude we are considering. This gives an intensity $N=1\times10^{-2}$ cm^{-2} sec.$^{-1}$.

(4) The frequency of the showers for which the density is larger than Δ is given by

$$F(\Delta)=K\Delta^{-\gamma}$$

where K and γ vary with Δ slowly enough to be considered as constants over a rather large range of densities.[4]

The number e_S of electrons belonging to air showers falling on the surface s in the unit time is then:

$$e_S=\int_{\Delta_{\min}}^{\infty}\frac{dF}{d\Delta}(1-e^{-s\Delta})d\Delta$$

$$=\frac{sK}{\Delta_{\min}^{(\gamma-1)}}\left\{1+\frac{1}{\gamma-1}+\frac{(s\Delta_{\min})^{\gamma-1}}{(\gamma-1)(\gamma-2)}\Gamma(3-\gamma)\right\}. \quad (1)$$

This formula shows that the main contribution to e_S comes from showers with densities near $\Delta_{\min}$, hence it justifies the assumption that K and γ are constants, provided that they satisfy the experimental spectrum near $\Delta_{\min}$. As discussed previously, the value of $\Delta_{\min}$ depends on the surface of the apparatus used to detect the showers. In reference 4, the maximum counter surface used was 0.5 m², which corresponds to an average density of about 5 particles per m². As a contribution to this average density comes from showers whose density is about 10 times smaller, the experimental results show that a power spectrum holds down to $\Delta_{\min}=0.5$ m^{-2} with $K=1.29$ and $\gamma=1.25$ (Δ in m^{-2}, time in sec.). With $s=1$ cm$^2=10^{-4}$ m², from formula (1), one has

$$e_S=7.5\times10^{-4}\text{ cm}^{-2}\text{ sec.}^{-1}.$$

(5) Using the result[5] that in the extensive showers the ratio

$$R_\mu=\frac{\mu\text{-meson density}}{\text{electron density}}=\sim2\times10^{-2},$$

we obtain

$$\mu_S=e_S\times R_\mu=1.5\times10^{-5}\text{ cm}^{-2}\text{ sec.}^{-1}.$$

(6) Using the result that[6]

$$R_N=\frac{N\text{-component density}}{\text{electron density}}=\sim1\times10^{-2},$$

we obtain

$$N_S=e_S\times R_N=7.5\times10^{-6}\text{ cm}^{-2}\text{ sec.}^{-1}.$$

The ratios between these figures and the figures previously given for the various components of the total cosmic radiation, are

$$e_S/e=1/11,\quad \mu_S/\mu=1/1600\quad\text{and}\quad N_S/N=1/1300.$$

The ratio 1:11 found for electrons shows that our estimate accounts for about 10 percent of the electrons in the soft component (excluding the electrons due to decay and knock-on processes of μ-mesons). As pointed out before, our estimate does not include the electrons belonging to showers whose density is smaller than 0.5 cm^{-2}, which are certainly very numerous. In fact, such low electron densities must occur very frequently, since they are produced: (a) by showers of rather small energies which are almost exhausted at the level of observation; (b) by energetic showers whose core strikes very far from the surface s considered. These last events are not very frequent, but the enormous surface they cover makes their probability of being recorded very high. In fact, except for the gradual decrease of γ in the density spectrum for small values of Δ, the integral in Eq. (1) would diverge.

With these arguments in mind, we feel justified in concluding that it is not unlikely that all electrons which are not secondaries of μ-mesons present in the cosmic radiation, are accounted for by the electrons belonging to extensive air showers.

The situation is not necessarily different for μ-mesons and for the particles of the N-component, notwithstanding the fact that our estimates cover only very small fractions of the corresponding total intensities in the cosmic radiation. In fact, one must keep in mind that our estimates refer only to those particles which arrived at the surface s accompanied by ionizing particles with densities larger than 0.5 m^{-2}. Now, since in air the ***absorption*** lengths of the μ-mesons and of the N-component are about 2000 g/cm² and 160 g/cm², respectively, while the absorption length of low energy electrons is about 40 g/cm², one must expect the mesons and the nucleons to survive longer than the electrons, hence to arrive in the lower atmosphere accompanied by ionizing particles with extremely low densities. On the other hand, evidence has been found[7] that an appreciable fraction of the penetrating showers do not contain any electro-magnetic radiation. If this kind of process is possible at high energies, part of the penetrating component could be created without the accompanying electrons of the extensive showers.

Support for the hypothesis that all particles observed in the lower atmosphere are generated in extensive showers, is provided by the facts that, whenever three or more coherent penetrating particles coming from the air have been recorded, an extensive shower accompanying them has been recorded too; and that the probability of recording an extensive shower accompanying the N-component increases when the energy of the N-component increases.[8]

[1] We disregard here the tail of primary radiation which may cross the atmosphere without interacting with any nucleus of the air.
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Disintegration Scheme of Scandium [46]

B. N. SORENSEN,* B. M. DALE, AND J. D. KURBATOV
Department of Physics, Ohio State University, Columbus, Ohio
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THE disintegration of the ground state of Sc^{46} was described previously as a complex beta-decay followed by emission of two successive gamma-rays. The predominant disintegration was found to be beta-emission of 0.36 Mev. The relative abundance of a second beta-emission of 1.49 Mev was determined to be six percent and later this was reduced to two percent.[1] In subsequent work with a magnetic lens spectrometer and coincidence counter these results on the beta-disintegration of 1.49 Mev were not confirmed.[2–4]

In recent work the successive emission of gamma-quanta of 1.12 Mev and 0.89 Mev by excited states of Ti^{46} was designated as electric quadruples with no change in parity.[5] Consequently additional information on the 1.49-Mev beta-decay would be of value in assignment of the angular momentum of Sc^{46}.

For the present work scandium oxide was activated by neutrons at the Oak Ridge National Laboratory. This was chemically purified and first studied with G-M coincidence counters. The arrangement of the coincidence counters allowed the use of G-M tubes of different potentials with resolving time of about 10^{-7} sec.

From determinations of beta-gamma- and gamma-gamma-coincidences the following results were obtained. The end point at 110 mg cm^{-2} of Al for the emitted beta-radiation in coincidence with gamma was in agreement with the previous value known for the beta-disintegration of 0.36 Mev. The beta-gamma-coincidences per beta recorded and gamma-gamma-coincidences per gamma recorded gave 5.01×10^{-3} and 2.50×10^{-3} values respectively. These correspond to a simple beta-spectrum followed by two gamma-rays in cascade with an upper limit for a second beta-disintegration of 0.2 percent.

With the aim of improving the upper limit of the second beta-disintegration Sc^{46} was studied in a cloud chamber. The sample was placed on zapon film and mounted in the center of the chamber. Eleven thousand tracks of electrons of energies less than 0.36 Mev were obtained in a magnetic field. Only twelve tracks were found having energies higher than 0.36 Mev. Of these ten electrons were in the range between 0.65 Mev and 0.9 Mev. With the assumption that some electrons in this energy range are due to scattering and to internal conversion of the gamma-rays emitted the upper limit for the beta-decay of 1.49 Mev in Sc^{46} can be estimated as less than 0.05 percent of the 0.36-Mev beta-disintegration.

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* Present address of Lt. Colonel B. N. Sorensen: U. S. Air Force, Washington, D. C.
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The Microwave Spectrum of BrCl

D. F. SMITH, M. TIDWELL, D. V. P. WILLIAMS
Carbide and Carbon Chemicals Division, K-25 Plant, Oak Ridge, Tennessee*
July 24, 1950

BY mixing Br_2 and Cl_2, an equilibrium is established between these two halides and BrCl. With equal amounts of Br_2 and Cl_2 at room temperature, a mixture containing roughly 60 percent BrCl is obtained rapidly, but because of the speed of reaction this BrCl is not separated readily.[1] An unseparated mixture has been employed to observe the transitions corresponding to the $J=0\rightarrow1$ rotational spectrum of BrCl in the region of 9000 Mc/sec.

Since there are two isotopes for Br and Cl, there are four isotopic species of BrCl. All of the nuclei have spins of $\frac{3}{2}$ and exhibit appreciable quadrupole coupling. In all, some 29 lines have been observed and their frequencies measured. Two of these lines correspond to the two strongest transitions of the molecules in the first excited vibrational state.

All of these lines have been identified, and the parameters of the molecule obtained using the method of Bardeen and Townes[2] for the first-order quadrupole coupling and for the second-order quadrupole coupling due to the bromine,[3] the latter being of the form $(eqQBr)^2/B$. Second-order coupling terms of the form $(eqQCl)(eqQBr)/B$ and $(eqQCl)^2B$ have not been included. The precision of the measurements does not justify introducing magnetic coupling terms of the form $c(\mathbf{I}\cdot\mathbf{J})$. In Table I the calculated values of the transition frequencies using the parameters given in Table II, are compared with the observed frequencies, and the differences are given. The designations are those of the final $J=1$ state. The average deviation of 140 kc/sec. is to be compared with the average probable error of the individual measurements of 110 kc/sec. For the $F_1=\frac{1}{2}$, $F=2$ transitions, the deviations are all anomalously large, but the manner of

TABLE I. Frequencies of BrCl transitions in Mc/sec.

Designation F_1	F	$Br^{79}Cl^{35}$ Observed frequency	Computed frequency	Dev.	$Br^{81}Cl^{35}$ Observed frequency	Computed frequency	Dev.
3/2	2	9307.96	9307.97	0.01	9209.57	9209.51	0.06
3/2	3	9291.61	9291.50	0.11	9193.26	9193.16	0.10
5/2	1	9088.61	9088.32	0.29	9026.17	9026.21	0.04
5/2	4	9080.73	9080.71	0.02	9018.40	9018.50	0.10
5/2	2	9074.91	9074.78	0.13	9012.97	9012.83	0.14
5/2	3	9063.77	9063.91	0.14	9001.44	9001.63	0.19
1/2	2	8899.50	8899.87	0.37	8865.66	8865.26	0.40
5/2	$4 v=1$	9034.14	9034.27	0.14	8972.41	8972.50	0.09
			$Br^{79}Cl^{37}$			$Br^{81}Cl^{37}$	
3/2	2	8964.19	8964.18	0.01	—	8865.82	—
3/2	3	8951.38	8951.36	0.02	8852.93	8852.97	0.04
5/2	1	8745.17	8745.20	0.03	8683.06	8682.72	0.34
5/2	4	8738.47	8738.71	0.24	8676.37	8676.37	0
5/2	2	8733.84	8733.83	0.01	8671.87	8671.66	0.21
5/2	3	8725.49	8725.40	0.09	8663.40	8663.22	0.18
1/2	2	8559.58	8559.15	0.43	8525.53	8626.03	0.50