Distribution of Cosmic-Ray Nuclear Disintegration in Time

In connection with the investigations of W. F. G. Swann and the authors on nuclear disintegrations produced by cosmic rays,[1] the question arose as to whether these disintegrations occurred individually and collectively at random in time. To test this, observations were taken for a thirty-five hour period with the large ionization vessel and recording system previously described. The time intervals between the occurrence of bursts of ionization larger than four million ions in nitrogen at a pressure of 100 pounds per square inch were measured, and the number of intervals between certain limits were obtained. These data were compared with the numbers to be expected by the method used by Marsden and Barratt[2] for alpha-particles. If n is the number of intervals and τ is the average interval, then n is given by

$$n=N(e^{-t_1/\tau}-e^{-t_2/\tau}).$$

TABLE I.

t_1 (sec.)	t_2 (sec.)	n calculated	n observed	difference r	divergence $r^2/n_{\text{calc.}}$
0	50	19.38	22	+1.62	0.14
50	100	17.89	17	−0.89	0.04
100	200	30.46	26	−4.46	0.65
200	500	63.47	68	+4.53	0.32
500	1000	50.48	47	−3.48	0.24
1000	2000	26.62	31	+4.38	0.72
2000	5000	4.69	2	−2.69	1.54
5000	∞	0.01	0	0	
Totals		213.00	213	$\chi^2=3.65$ $\tau=521.6$ sec.	

The agreement between these expected numbers and the observed ones can be seen from Table I. The fit between the observed and calculated values has been measured by Pearson's criterion and the value of χ^2 obtained is given in the last column. From distribution tables of χ^2 we find[3] that the probability of a divergence greater than this is between 0.7 and 0.5. Thus the data are in good accord with the hypothesis that the nuclear disintegrations observed are randomly distributed in time.

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[1] W. F. G. Swann and C. G. Montgomery, Phys. Rev. **44**, 52–53 (1933).

[2] Marsden and Barratt, Proc. Phys. Soc. **23**, 367 (1911); **24**, 50 (1911); Rutherford, Chadwick and Ellis, *Radiations from Radioactive Substances*, p. 172, Cambridge, 1930.

[3] T. C. Fry, *Probability and its Engineering Uses*, p. 468, New York, 1928.

Neutrons from Cosmic-Ray Stösse

Some preliminary results of the cloud photography of cosmic-ray Stösse, or ionization bursts, in argon, seem sufficiently interesting to be described here. Numerous neutron-recoil atom tracks, two long nucleus tracks, and groups of simultaneous tracks that converged at different points, were found.

A cloud chamber 15 cm in diameter has been arranged to be set off immediately after the simultaneous discharge of 3 Geiger-Müller cosmic-ray counting tubes, placed with two above and one below the chamber, but as far *out of line* as possible. The principle of its operation is similar to that of the apparatus of Blackett and Occhialini,[1] except that the counters are not set off by single rays. Of the triple-coincidence counting rate, 1.26 hr.$^{-1}$, it is estimated from the photographs taken that about one-third of the discharges are from Stösse and two-thirds from branched tracks, double tracks, and so on. Surrounding the chamber are 1350 lb. of massive material, consisting of 750 lb. of lead, 400 lb. of copper and brass, and 200 lb. of iron. A cloud atmosphere of argon at 64.5 cm pressure is used. The specific ionization of tracks in argon is high; the relatively high viscosity makes the tracks persist better than tracks in air; the expansion ratio is small (1.18, as compared with 1.3 for air), and the probability of obtaining recoil atoms from any neutrons present is relatively high. Since the ionizing particles traverse the chamber about 0.01 sec. before the expansion, the tracks are somewhat diffused by thermal agitation and the expansion; equality of diffuseness of tracks of like densities serves to establish approximate simultaneity of their formation, and makes it easy to discriminate between pre- and post-expansion tracks.

Figs. 1, 2, and 3 are stereophotographs of interesting

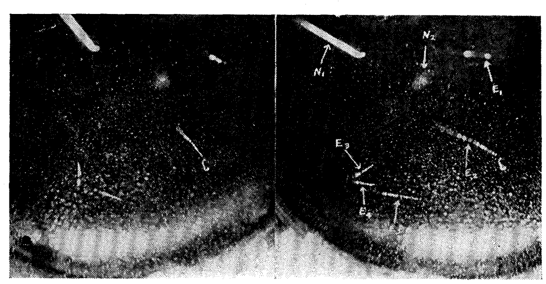

FIG. 1. Stoss with 2 nucleus tracks (N), and 5 electron tracks (E). E_1, E_2 and N_1 converge at a point in the lead, above and behind the chamber. E_3, E_4 and E_5 converge at another point. N_2 is believed to be an argon atom recoiling after elastic collision with a neutron. The heavy nucleus track, N_1, ends in the chamber with a sharp bend. (Mag. ×0.35)

[1] Blackett and Occhialini, Proc. Roy. Soc. (London) **A139**, 699 (1933).