The Dependence of Burst Production Upon Atomic Number

In previous communications[1] we have suggested that the rate of occurrence, RdN, of cosmic-ray bursts having a number of ionizing rays between N and $N+dN$, may be represented over a large range of burst sizes by the expression

$$RdN = A/N^s dN, \tag{1}$$

where A and s are parameters and presumably functions of the atomic number, Z, of the burst producing substance. For the bursts from lead, s was found to be about 3.2. To determine the dependence of these parameters upon Z, we have made observations on the numbers of bursts originating in small thicknesses of paraffin, Mg, Fe, Sn and Pb. The bursts were detected in an ionization chamber which consisted of three spherical steel chambers, placed at the corners of a triangle. Each chamber had a diameter of three inches, a wall thickness of a millimeter, and was filled with argon to a pressure of 300 lb. per square inch. A vacuum tube electrometer with photographic recording was employed. The rate of occurrence of bursts greater than 1.6×10^5 ion pairs was determined for each substance. The number of bursts occurring when no material was over the chambers was also measured, and subtracted from the observations taken with the burst producing material present. The rate of occurrence of bursts per atom of the producing material was found to be proportional to the square of the atomic number. The results are illustrated in Fig. 1. Through the point for lead in this figure a line with a slope corresponding to a Z^2 variation has been drawn. It fits the other points satisfactorily with the possible exception of the observations on paraffin. This substance produces so few bursts, however, that it is questionable whether any significance should be attached to this apparent exception.

A similar result has been obtained for bursts of different ranges of sizes by other observers. B. Rossi[2] measured the rates of occurrence of small showers from Pb, Fe and Al by means of Geiger-Müller counters. H. Nie[3] has recently made observations upon very large bursts in an ionization chamber over which were placed these same three substances. Both these sets of observations are as well satisfied by a Z^2 law of variation as the observations reported here upon bursts of an intermediate size. Thus there is good evidence that expression (1) above may be written so as to contain the dependence upon atomic number explicitly as

$$RdN = BZ^2/N^s dN,$$

where B and s are independent of Z.

We may draw two conclusions of significance from this. First, the simple variation with Z^2 suggests that the fields of the nuclei of the burst-producing materials, rather than their particular nuclear structures, are of prime importance, and that it is quite probable that the nuclei remain intact under the impact of the cosmic rays. Second, the picture of a burst being built up by a successive doubling of the number of electrons by the mechanism of pair formation (with or without intermediary photons) is inconsistent with the observed Z^2 variation. Since the probability of each act of pair production, or of the production of intermediary photons, is proportional to Z^2, we should expect the probability of the composite process to vary with a much higher power of Z. We do know that some sort of building up process[4] is involved in the formation of bursts. The experiments here reported, however, seem to show definitely that this building up is not by pair formation, but must involve the simultaneous production of a large number of rays.

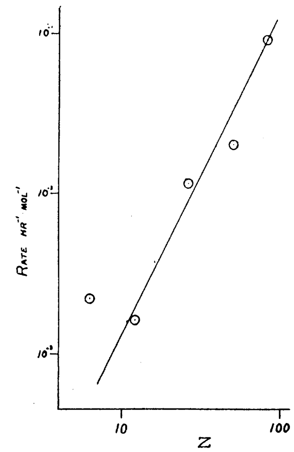

FIG. 1. Rate of production of bursts as a function of atomic number.

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C. G. MONTGOMERY
D. D. MONTGOMERY

Bartol Research Foundation of the Franklin Institute,
Swarthmore, Pa.,
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[1] C. G. Montgomery and D. D. Montgomery, Phys. Rev. **48**, 786 (1935); **48**, 969 (1935).
[2] B. Rossi, Zeits. f. Physik **82**, 151 (1933).
[3] H. Nie, Zeits. f. Physik **99**, 787 (1936).
[4] C. G. Montgomery, D. D. Montgomery and W. F. G. Swann, Phys. Rev. **47**, 512 (1935).

The Scattering of Neutrons by Protons

We have measured the scattering by protons of neutrons having an energy in the intermediate region by using the homogeneous neutrons from a carbon target bombarded by a monoenergetic deuteron beam, and our results are in satisfactory agreement with the predictions of Wigner's formula, contrary to the results of Goldhaber.[1] The apparent equality of the proton-proton and proton-neutron interactions, deduced by Breit, Condon, and Present on the basis of our measurements on proton-proton scattering, has made it of special interest to test in every possible way the validity of the current theoretical representation of the proton-neutron interaction.

Our first measurements, which gave approximate agreement with Wigner's formula as described at the Johns Hopkins Gibson Island Conference (June 24, 1936) and the Cornell Conference (July 4, 1936), duplicated Goldhaber's geometry and his paraffin-boron detector in order