Wide Angle Sprays of Minimum Ionization Particles*

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We have observed wide angle sprays of soft minimum ionization particles emerging from lead plates of a cloud chamber. The cloud chamber was expanded at regular intervals of one per minute, and the pictures were taken during three hours at constant altitude of 14 g/cm^2. The cloud chamber was in a pressurized gondola attached to a General Mills balloon that had been launched from Camp Ripley at 55° geomagnetic latitude.

Figure 1 shows an example of one of the largest of such sprays in which it is possible to count about 30 tracks. Stereoscopic viewing shows that most of the tracks remain in the illuminated region as they traverse the section between the two $\frac{1}{4}$-in. lead plates; however, none of the spray particles appear to traverse the lower lead plate. Since the observed tracks show minimum ionization and have a range less than $\frac{1}{4}$ in. of Pb, they are probably electrons, and, in any event, have a mass not larger than about 20 electron masses. There is no indication of any further cascade process associated with the spray in Fig. 1.

In Table I we have tabulated the sprays observed during three hours during one of our flights. Although the events have been observed on several flights, we have used only this one in the tabulation because the condition of the chamber was particularly constant during this time.

The minimum ionization events reported in Table I certainly involve more than one type of phenomenon. Some of the events exhibit the narrow angle penetrating sprays that have been observed to emerge from "stars" seen in photographic emulsions. However, the fraction of soft wide angle sprays with and without associated heavy particles seems to be approximately independent of the size of the spray. The fact that the "star" particles are seen in only about one-third of the observed cases does not imply that the remaining two-thirds events were not accompanied by a star. From observations in photographic emulsions one would conclude that the range of most of the nucleons emerging from stars is not great enough to penetrate $\frac{1}{8}$ in. of lead.

Table I. Minimum ionizotion sprays.*

Number of particles with between one and two times min. ionization	3 or more	3—5	6—9	10—15	>15
Number of events with min. ionization particles	100	56	31	10	3
Number of cases where spray is accompanied by heavily ionizing particles	34	20	10	3	1
Number of events in which one or more spray particles penetrate $\frac{1}{4}$ in. Pb	19	10	7	1	1
Number of events in which one or more spray particles multiply in $\frac{1}{4}$ in. Pb	10				
Number of stars of heavy particles and no min. ionization tracks in the same operating time	9				

* Not all sprays included are wide angle.

In the spray reproduced in Fig. 1, as well as in several other large angle sprays, it is impossible to project all the observed tracks back to a common center. Instead, several groups seem to emerge from a region in the lead plate about $\frac{1}{2}$ cm in diameter. Since the observed sprays thus may be formed in some multiple type of event, we have looked for stars or sprays in the lead plates above and below the plates in which the sprays themselves were observed. The probability that a moderate energy gamma-ray will be degraded in only $\frac{1}{4}$ in. of Pb is not very large, and one might therefore expect to find small sprays in several plates. Some of the minimum ionization particles observed throughout the chamber may be associated with a star in the picture. However, there is only one case in the 100 events of Table I where the association appears at all plausible. Figure 2 shows an example from another flight in which a star may be time-coincident with a spray. Because of the difficulty of deciding the average direction of momentum transfer to the spray, and because of the large number of random tracks in the cloud chamber, it has not been possible to determine whether the sprays are initiated by ionizing or non-ionizing radiation.

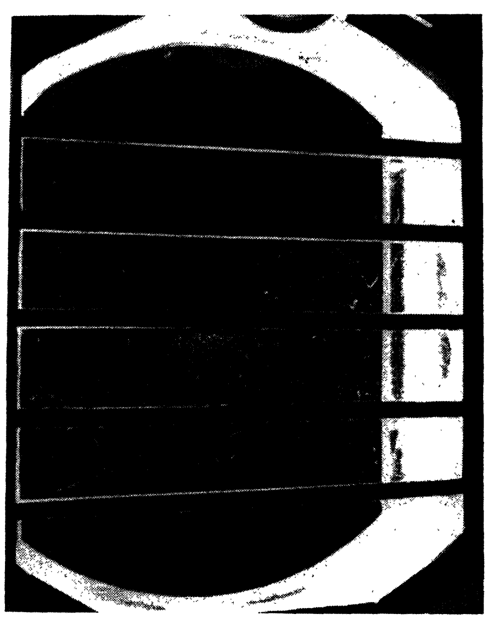

Fig. 1. A minimum ionization spray containing about 30 particles obtained at a residual pressure of 1.1 cm of mercury.

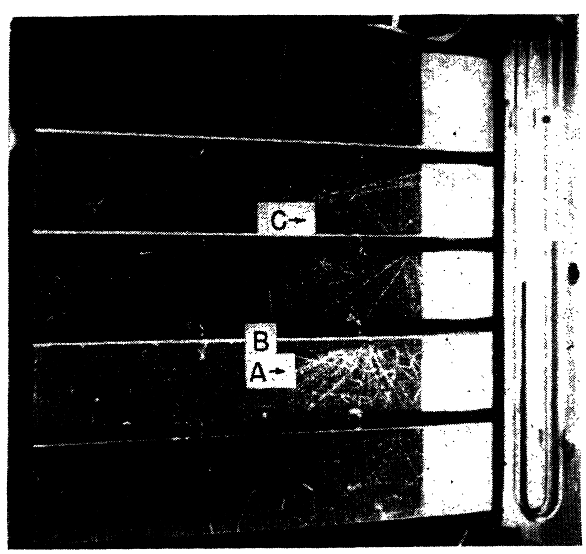

Fig. 2. A minimum ionization wide angle spray (A) consisting of at least 45 particles. This spray originates in the $\frac{1}{4}$-in. lead plate (B). The space between the spray and the lead plate arises because the tracks are post-expansion and the gas next to the plate has been recompressed. Approximately time-coincident with the spray is the star at the top and near the right of lead plate (C). The residual pressure of 1.8 cm of mercury is indicated by the mercury manometer on the right.

It is possible that the observed large angle sprays of electrons are due to the tail of large cascade showers whose core is traveling more or less parallel to the lead plates. There is little direct evidence against this explanation of the sprays. However, there are three factors which make it appear to be unlikely. (1) The frequent appearance of heavy particles associated with sprays. (2) The fact that only two large cascade showers, at any angle to the plates, have been observed in all the pictures we have obtained above 90,000 ft. (3) According to other workers, the appearance of such sprays of electrons is a very rare event to mountain and B-29 altitudes, even though the relative frequencies of showers as compared to stars is much greater at these lower altitudes than in out flights.[1] At 90,000 ft. the wide angle sprays are quite frequent. The cloud-chamber sensitive time represented in Table I is about 3.5 sec.

We plan to continue to gather statistics of the occurrence of the sprays reported here. Although we have now observed five carbon interactions, we have not observed any sprays initiated in carbon. We hope, in the future, to be able to measure the momentum of the spray particles.

The balloon flights and the development of the cloud-chamber equipment of this work has been made possible through the assistance of the ONR and the AEC.

* Reported at the Echo Lake Conference of Cosmic Rays, June 22–28, 1949.
[1] An event which appears to be of the type described here has been seen by R. P. Shutt, Phys. Rev. **69**, 271 (1946).

The Determination of the Molecular Structure of Bromosilane by Microwave Measurements

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THE second and third rotational transitions, $J=1\rightarrow 2$ and $J=2\rightarrow 3$ of $Si^{28}H_3Br^{79}$ and $Si^{28}H_3Br^{81}$, have been measured and analyzed. The $J=2\rightarrow 3$ transition of the rarer isotopic species of bromosilane, $Si^{29}H_3Br^{79}$, $Si^{29}H_3Br^{81}$, $Si^{30}H_3Br^{79}$, and $Si^{30}H_3Br^{81}$, were also observed. The nuclear and molecular constants are listed in Table I.

TABLE I. Nuclear and molecular constants of bromosilane.

		ν_0(mc/s)	$I_B\times 10^{40}$ (g-cm²)	$eQ(\partial^2V/\partial Z^2)$ (mc/s)	B_0(mc/s)
$J=2\rightarrow 3$	$Si^{28}H_3Br^{79}$	25930.32	194.13	336	4321.72
	$Si^{28}H_3Br^{81}$	25755.89	195.44	278	4292.64
	$Si^{29}H_3Br^{79}$	25397.80	198.20		4232.96
	$Si^{29}H_3Br^{81}$	25222.21	199.58		4203.70
	$Si^{30}H_3Br^{79}$	24896.33	202.19		4149.39
	$Si^{30}H_3Br^{81}$	24720.57	203.63		4120.09
$J=1\rightarrow 2$	$Si^{28}H_3Br^{79}$	17287.30	194.12		4321.82
	$Si^{28}H_3Br^{81}$	17170.45	195.44		4292.61

The theoretical hyperfine structure to be expected for a nuclear spin of 3/2 for beomine was in excellent agreement with the observed spectra for all the transitions involving Si^{28}. Since the second order quadrupole corrections were of the same order as the experimental error in frequency measurement (±0.08 mc/s), they were neglected. These measurements yield a ratio of 1.209 for the nuclear quadrupole moment of Br^{79} to that of Br^{81} which compares favorably with the figure of 1.197 for the corresponding methyl bromides.[1] Any possible quadrupole effect due to the Si^{29} or Si^{30} nuclei was sufficiently small as to be within the limits of resolution.

The experimental determination of six effective moments of inertia resulting from the different isotopic species permits the evaluation of the three structural parameters of the molecule. These were evaluated from the $J=2\rightarrow J=3$ transitions of $Si^{28}H_3Br^{79}$, $Si^{28}H_3Nr^{81}$, and $Si^{30}H_3Br^{79}$ and checked against the remaining three. The values are listed together with the estimated errors in Table II.

TABLE II. Structural parameters for bromosilane and chlorosilane.

	SiH_3Br	Covalent radii and tetrahedral angle	SiH_3Cl[2]	Covalent radii and tetrahedral angle
Si-Br Distance	2.209±0.001A	2.31	2.048A	2.16
Si-H Distance	1.57±0.03A	1.47	1.50A	1.47
H-Si-H Distance	111°20′±1°	109°28′	110°57′	109°28′

As observed with SiH_3Cl, there is considerable shortening of the Si—Br distance from the sum of the covalent radii, presumably due to appreciable double bond character of this bond. However, the difference of the Si—Cl and the Si—Br distances is the same as that of the corresponding covalent radii. Although not stated explicitly,[2] the number of significant figures available in the chlorosilane parameters may be expected to be the same as that in bromosilane; hence differences in these parameters listed in Table II are not necessarily real.

We wish to thank Dr. A. E. Newkirk of this laboratory for the preparation of the bromosilane used in these measurements.

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[1] Gordy, Simmons, and Smith, Phys. Rev. **74**, 243 (1948).
[2] Computed from microwave measurements. See Dailey, Mays, and Townes, Phys. Rev. **76**, 136 (1949), and A. H. Sharbaugh, Phys. Rev. **74**, 1870 (1948).

Erratum: The Application of Dyson's Methods to Meson Interactions

[Phys. Rev. **76**, 486 (1949)]

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IN Eq. (6) the closures of the brackets in the factors of the form $P(\ldots)$ should follow the factor $j(x_n)$ in the first two terms and the factor $(j_\rho(x_{n-1})n_\rho(x_{n-1}))^2$ in the final term.

On the Photoelectron Spectrum of Ta^{182}

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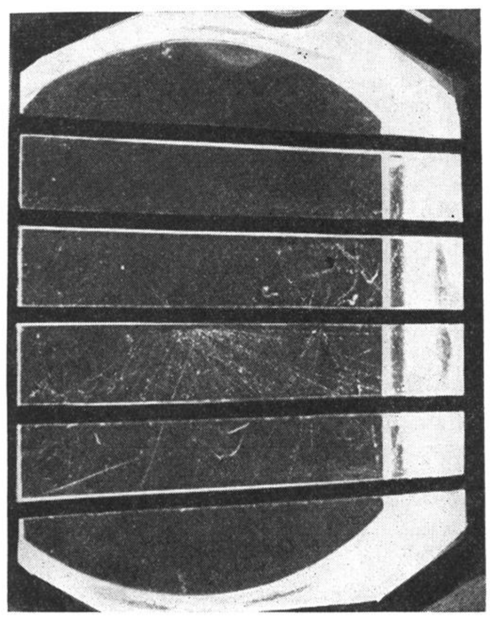
September 16, 1949

A STUDY of the internal conversion electrons produced by the gamma-rays from the disintegration of Ta^{182} has led to a report[1] of some 28 gamma-rays in the energy range below 330 kev. The investigation herein reported is a study of the photoelectron spectrum of this isotope using a 14-cm radius of curvature uniform field spectrometer.[2] The only other reported investigation[3] of the photoelectron spectrum of this isotope gives only two gamma-rays in the above-mentioned region and two higher energy gammas at 1.13 and 1.22 Mev.

The region for gamma-ray energies below 330 kev was studied using both uranium and lead radiators, each of 50 mg/cm² thickness and the results are indicated in Parts (A) and (B) of Fig. 1, respectively. The higher energy region was studied only with the uranium radiator and the result is shown in Part (C) of Fig. 1.



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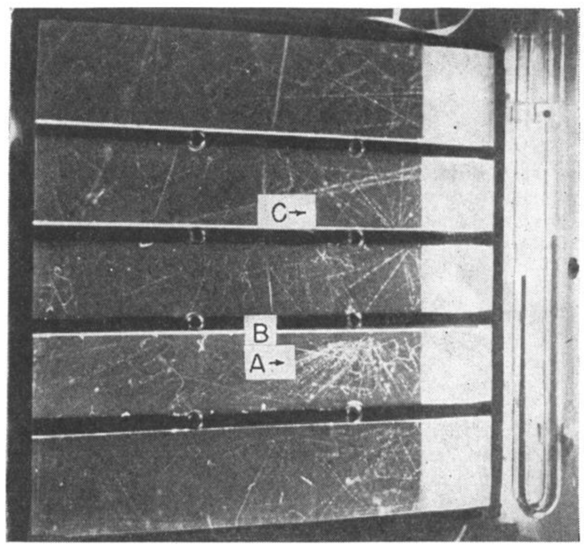

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