shield, one inch thick, in the shape of half a cylinder placed above the chamber. The measurements at high altitude were made in a B-29 aircraft. The biases of the four-channel discriminator were adjusted to record pulses larger than 1.1, 1.5, 2.0, 2.5 times the α-particle pulses, respectively. The observed burst-rates are listed in Table I (figures in parenthesis are actual numbers of bursts recorded). At all elevations the burst-rate with lead is 1.5 to 2 times as large as without lead. The variation of burst-rate with atmospheric depth can be represented approximately by function of the type $\exp(-x/L)$, where x is the atmospheric depth and $L=150$ g/cm^2.

We tenatively interpret the bursts observed without lead as produced partially by air showers, but for the most part by cosmic-ray induced nuclear disintegrations ("stars").[1] The increase in burst-rate caused by the lead is attributed to shower production in the lead by high energy electrons and photons. As an indication of the energies involved, we may mention that an electron of 10 Bev produces, on the average, in one inch of lead, a shower of 140 electrons which, by traversing the chamber in a direction perpendicular to the axis, give rise to a pulse of an average rise twice that of an α-particle. Since it seems that one inch of lead does not appreciably change the burst-rate from stars,[1] the variation with height of the "lead difference" (burst-rate with lead minus burst rate without lead) is representative of the variation with height of the number of high energy electrons and photons. This is true even if an appreciable fraction of the bursts observed under lead are produced by air showers because, in a qualitative sense at least, it is immaterial whether the showers recorded originate from single electrons or photons striking the lead or have partially developed in air before reaching the lead.

The large increase in the number of high energy electrons and photons, shown by the results in Table I, provides crucial evidence against the hypothesis that all cosmic-ray electrons and photons arise from the decay of ordinary mesons. Since the number of mesons in the range above 10 Bev does not change substantially from sea level to 35,000 feet, the intensity of their decay products should only increase inversely proportional to the air density; i.e., by about a factor of four.

Besides the disintegration of ordinary mesons, two other possible sources of electrons and photons have been considered at various times, namely (a) the existence of an electron and/or photon component in the primary radiation, and (b) the disintegration of short-lived mesons. From both hypotheses one predicts a rapid variation with height of the electron-photon intensity in the lower part of the atmosphere. According to hypothesis (a), however, the intensity should keep on increasing up to the top of the atmosphere *provided one only considers electrons and photons of energy larger than the geomagnetic cut-off*. According to hypothesis (b), instead, the intensity should go through a maximum and drop to zero at the top of the atmosphere. It is hoped that experiments at higher elevation than the present ones will make a decision between hypothesis (a) and (b) possible.

If our analysis is correct, Table I shows that the intensities of the "star producing radiation" and of the electron-photon component vary approximately by the same factor from 0 to 35,000 feet. Since this can hardly be an accident and since stars do not seem to be produced by electrons or photons,[1] one is led to the conclusion that the star producing radiation and the electron-photon component are both in equilibrium with a common parent radiation, a result which can be brought into agreement more easily with hypothesis (b) than with hypothesis (a).

TABLE I. Dependence of burst rates on altitude.

Altitude (feet) Atmospheric depth (g/cm^2)	Lead	Burst-rates (per hour) $>1.1\alpha$	$<1.5\alpha$	$<2.0\alpha$	$<2.5\alpha$
0 (1030)	On	4.0 (209)	1.7 (112)	1.32 (70)	0.67 (44)
	Off	*	*	*	*
14,000 (610)	On	51 (152)	30 (90)	20 (61)	14 (42)
	Off	36 (132)	20 (74)	13 (47)	6.3 (23)
25,000 (388)	On	286 (476)	149 (375)	93.8 (236)	57.3 (144)
	Off	141 (242)	87.8 (262)	54.6 (163)	32.2 (96)
30,000 (310)	On		289 (231)	156 (125)	97.5 (78)
	Off		158 (213)	90 (122)	63 (85)
35,000 (248)	On	786 (800)	453 (461)	267 (271)	175 (178)
	Off	420 (406)	238 (230)	133 (129)	81.6 (79)

* The ratio of bursts per hour with lead on to those with lead off was determined as 2.1 for this range of pulse heights with slightly different equipment.

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[1] This view is supported by the preliminary results of experiments by R. W. Williams at 11,000 feet altitude, which are now in progress. See also D. Skobeltzyn, Phys. Rev. **70**, 441 (1946).

A Metastable State of Half-Life about 10^{-6} Second in Re^{187}

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USING sources of W^{187} (24 hrs.) and an experimental arrangement similar to that described in a previous letter,[1] we were able to detect delayed coincidences whose number as a function of time is shown in Fig. 1. It appears from this curve that the disintegration of W^{187} leads to a metastable state Re^{187*}, which in turn decays to the ground state with a half-life of about one microsecond (only statistical errors are indicated on the figure; errors involved in the calibration of the time-scale may be considerably larger).

In order to increase the counting rate by eliminating absorption in the counter windows, the two G-M counters

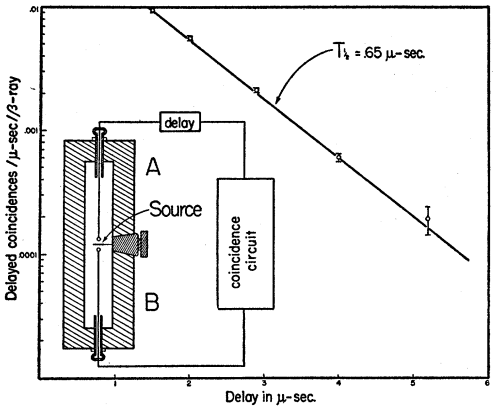

FIG. 1. Delayed coincidences *vs.* delay time from the disintegration of W^{187}.

and the source (deposited on a thin aluminum foil) were located within the same envelope (Fig. 1). Since the minimum delay used was 1.5μ sec. it was necessary to prove that the recorded coincidences were not due to simultaneous rays (immediate internal conversion, or radiation scattered from one to the other counter) which gave delayed pulses because of the time lag of the counters. To test this point β-rays from Ra*E* were sent through both counters, and it was found that these did not give any delayed coincidences despite the large number of immediate coincidences recorded.

Absorption measurements were performed under the geometrical conditions described in the previous letter[1] by use of two mica window G-M counters. The absorption curve of the disintegration electrons followed by a delayed ray proved that the metastable state follows the softer part of the β-spectrum[2] of W^{187}. Some γ-radiation also seems to precede the metastable state. From absorption measurements on the delayed electrons it appears that the energy of the delayed γ-rays may correspond to any one of the three soft lines (0.086, 0.101, or 0.130 Mev) previously observed in the spectrum of W^{187}. However, it seems probable that the metastable state is associated with the 0.130-Mev transition since this has been observed with a β-spectrometer to be strongly converted.[3]

The disintegration of the metastable state is accompanied by a soft electromagnetic radiation (less than 100 kev) which could be either the unconverted γ-ray from the metastable state (which in this case should be attributed to the 86-kev transition), or a γ-ray following it, or the atomic x-radiation from Re. The number of delayed electrons per disintegration of W^{187} was evaluated as 0.1. Since not all β-rays of W^{187} lead to the metastable state, the internal conversion coefficient must be larger than this value.

This work was done under the auspices of the Manhattan District.

[1] S. De Benedetti and F. K. McGowan, Phys. Rev. **70**, 569 (1946).
[2] W. H. Sullivan, Phys. Rev. **68**, 277 (1945).
[3] We are indebted to L. C. Miller and L. F. Curtiss for the communication of this result.

Metastable Ion Transitions in the Mass Spectra of the Monochloropropenes

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RECENTLY Hipple and Condon,[1] and Hipple, Condon, and Fox,[2] have called attention to the occurrence and origin of metastable ions which dissociate soon after traversing the electric field in a mass spectrometer. The authors have found an instance of this type of dissociation in the monochloropropenes in which the chlorine atom is lost from the ionized molecule after traversing the accelerating field. In this case the characteristic isotope ratio of about three to one for Cl^{35} to Cl^{37}, labels the metastable peaks and confirms the mass assignment. According to the theory of Hipple *et al.*, the effective mass, m^*, of the dissociating ion is given by the relation $m^*=m^2/m_0$, where m_0 and m are, respectively, the masses before and after dissociation. For monochloropropene, $m_0=76$ and 78, and in both cases, $m=41$. Therefore, $m^*=22.1$ and 21.6 for the metastable dissociation of Cl^{35} and Cl^{37}, respectively. The metastable peaks observed in monochloropropene are at the predicted positions, and the peak heights are in the ratio of 3 to 1 as expected. They are differentiated from normal peaks by being wider and more diffuse, and are roughly triangular in shape with a base 0.7 of a mass unit wide, compared with a normal peak width of 0.2 mass units.

The allyl chloride was obtained from Eastman Kodak Company and was used without further purification. The other monochloropropenes were obtained from Columbia Organic Chemicals Company as a cis-trans mixture of 1-chloro-1-propene, containing some 2-chloropropene as an impurity. The identity of the components was confirmed by combined data from the mass spectrometer and the fractional distillation curves. The original was fractionated at reduced pressure to obtain the separate isomers but because only a small sample was available an independent check on the purity of each fraction was impossible. At about 304 mm the boiling points of the 2-chloropropene, cis-1-chloro-1-propene, and trans-1-chloro-1-propene were -2°C, $+6$°C, and $+12$°C, respectively.

Table I lists the relative peak heights for the isomers of the monochloropropenes at the mass peaks in question. In view of the possible incomplete fractionation, the results indicate that the metastable transition may be completely absent in 1-chloro-1-propene. This offers an analytical aid

TABLE I. Some mass peaks of the monochloropropenes.

		Fraction containing			
m/e	Ion	2-Chloro-propene	(Cis)1-chloro-1-propene	(Trans)1-chloro-1-propene	3-Chloro-1-propene
21.6	$[Cl^{37}C_3H_5^+] \rightarrow C_3H_5^+ + Cl^{37}$	0.42	0.05	0.02	0.56
22.1	$[Cl^{35}C_3H_5^+] \rightarrow C_3H_5^+ + Cl^{35}$	1.3	0.15	0.05	1.7
35	Cl^+	5.9	5.3	4.2	7.0
41	$C_3H_5^+$	200.	232.	226.	300.
76	$Cl^{35}C_3H_5^+$	100.	100.	100.	100.
78	$Cl^{37}C_3H_5^+$	31.8	31.7	31.7	31.7