ence of (0.0183±0.0027) in the counting rate due to D_2 in 187.1 cm of D_2O at 22°C. This gives a photodisintegration cross section of (1.47±0.22) millibarns per deuterium nucleus.

I am grateful for the encouragement of Dr. R. R. Wilson throughout the course of this experiment.

* This work was supported by the ONR.

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[4] E. Swift, Jr., J. Am. Chem. Soc. 61, 198 (1939).

Erratum: Quantum Statistics of Fields

[Phys. Rev. 83, 125 (1951)]

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THE following changes should be made in the article with the above title:

Equations (2.5) and (2.11): The factor T should be omitted.

Equation (3.13) should read:

$$S/V=-(2\pi)^{-3}k\int_0^\infty \log\{1-\exp(-\hbar^2K^2/2mkT)\}4\pi K^2dK+\frac{1}{(2\pi)^3}\frac{1}{T}\int_0^\infty\frac{\hbar^2K^2}{2m\{\exp(\hbar^2K^2/2mkT)-1\}}4\pi K^2dK.$$

Equation (4.14): add the factor mc^2.

Cosmic-Ray Star Production in Argon at Sea Level*†

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THE sea level rate of cosmic-ray star production in argon has been measured by direct observation of the N-ray nuclear interactions in the gas of an ionization chamber contained in a cloud chamber. The ionization chamber, a $3\frac{3}{4}$ in. diameter and $\frac{1}{16}$-in. walled brass cylinder 8 in. in length, open at both ends, and having a $\frac{1}{16}$-in. steel central wire, is mounted coaxially with the cloud chamber which has a useful rectangular volume 10 in.×10 in. ×8 in. depth[1] (Fig. 1). The gas, argon at 75 lb-in.$^{-2}$ absolute pressure saturated with iso-amyl alcohol, is common to both the cloud chamber and ionization chamber. A burst occurring in the ionization chamber generates a pulse which is used to trigger the expansion mechanism. Rapid reduction of the cylinder voltage from minus 1400 volts to ground, after electron collection is over, prohibits any appreciable motion of the positive ions and thus permits observation of the tracks of the burst producing particles. The regions exterior and interior to the ionization chamber are illuminated with Amglo flashlamps and photographed stereoscopically. A photographed array of neon bulbs indicates which of the counters (each 1 in.×16 in. effective area) above the chamber are discharged in coincidence with a burst. The chamber was operated under a light roof in an insulated box and maintained within a few degrees of 37°C. Only those bursts releasing more than 7 Mev (1.3 Po-alpha) were permitted to trigger the chamber. Oscillograph traces of the ionization chamber pulses were photographed.

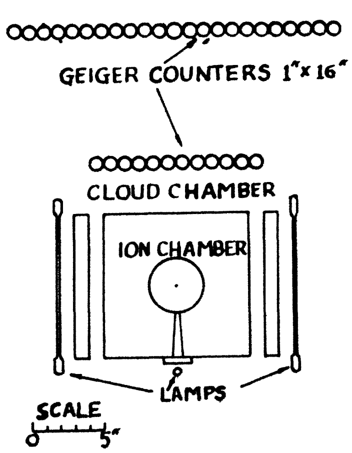

Fig. 1. Arrangement of ionization chamber, cloud chamber, and counters.

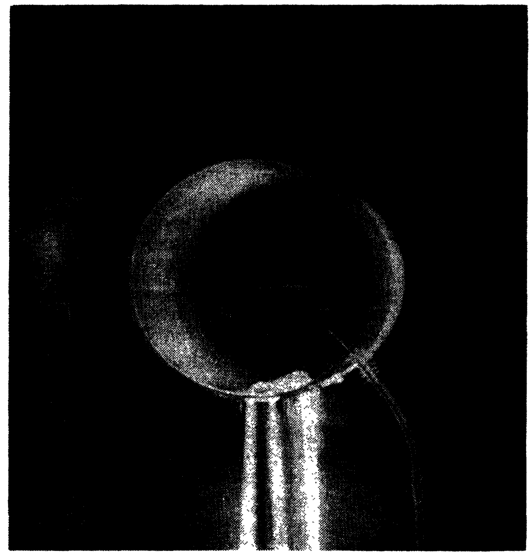

Fig. 2. A neutral particle interacts with an argon nucleus to produce a star in which 11 emitted ionizing particles are visible in the original negative. Protruding through the wall at the lower right is a wire carrying a Po-alpha calibrating source.

Bursts were produced by stars occurring in the wall and gas (see Fig. 2) of the ionization chamber and by electronic showers. In Table I the numbers of the above ionizing phenomena causing bursts in 365 hours of sensitive operating time are given. A plot of the spacial distribution of the origins of the stars occurring in the gas indicated that those occurring near the wall and the ends of the ionization chamber had less chance of being detected than those occurring nearer the axis and center of the chamber. In a centrally located cylindrical volume 7.16 cm in diameter and 12.2 cm long, where the wall and end effects are negligible, 37 stars of 1 or more prongs occurred in the gas in the sensitive time interval. Of these 27 were of three or more prongs. Since the photographs of the oscillograph traces of the bursts indicated the ionization chamber was working properly during this interval, the few instances in which blank pictures of the cloud chamber were obtained were attributed to inefficiency in the cloud chamber operation. The rate of star production in argon, after correcting

Table I. Number of ionizing phenomena causing bursts.

Sensitive time, hr	Stars in brass wall of 1 or more prongs	Stars in argon: 1 or more prongs	Stars in argon: 3 or more prongs	Bursts due to electronic showers
365	135	46	33	14

for this inefficiency (7 percent) and for the expansion of the gas (15 percent) is 0.78±0.13 g^{-1} day^{-1} and 0.57±0.13 g^{-1} day^{-1} for one or more and three or more prongs, respectively. The ratio of the latter rate to the rate measured in photographic plates[2] is 1.42±0.34, while the ratio of the nuclear area per gram of argon to that of the photographic emulsion, not counting the hydrogen present, is 1.17. Our results are thus not in disagreement with the emulsion work if N-rays have geometric cross section for nuclear interaction.

In a total operating period of 1009 hours, during which the chamber was not always operating at high enough efficiency for absolute rate measurements, the total number of gas stars observed was 95. In 5 cases the initiator was identified as a charged particle by its low ionization, its location in the upper hemisphere with reference to the star origin as center, and by the requirement that the backward extension of its path pass through counters above the cloud chamber which were discharged in coincidence with the ionization chamber. If charged and neutral N-rays have the same mean free path for nuclear interaction, this indicates that about 5 percent of the sea level N-rays are charged.

The authors are grateful to Professor W. M. Nielsen for his interest in the project and for his efforts which made the work possible.

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† Based in part on a thesis to be submitted by E. W. Hones to the Graduate School of Duke University in partial fulfillment of the requirements for the Ph.D. Degree.

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Induced Infrared Absorptions of H_2, N_2, and O_2 in the First Overtone Regions

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INFRARED absorptions at the fundamental frequencies have been observed in the compressed gases H_2, N_2, and O_2 and in mixtures of these with foreign gases.[1-3] The experimental evidence is consistent with the hypothesis that the absorption is caused by the distortion of the charge distribution of the absorbing molecule during a close two-body collision. The theoretical calculations of Van Kranendonk and Bird[4] support this hypothesis. In recent experiments on H_2, N_2, and O_2 at high densities, absorptions in the regions of twice the fundamental frequencies have been observed.

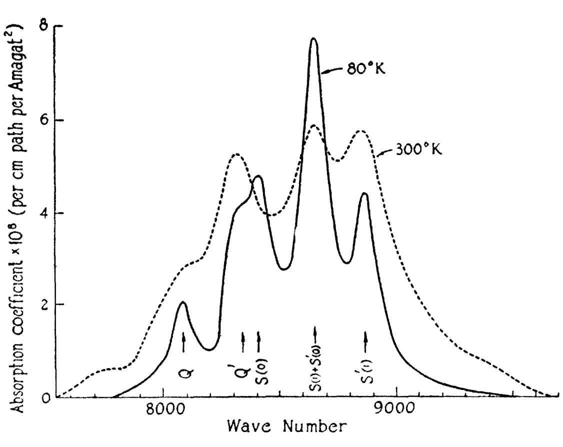

FIG. 1. Contours of the induced infrared absorption of hydrogen in the overtone region.

These absorptions were obtained using two transmission cells: a medium pressure (150 atmos) cell of 85-cm path length, and a high pressure (1500 atmos) cell of 30-cm path length. The medium pressure cell could be cooled to liquid air temperatures, and was used to investigate the temperature dependence of the H_2 absorption.

The integrated absorption coefficient of the overtone absorption in H_2 at both 80°K and 300°K varies as the square of the density up to 426 and 676 Amagat, respectively. The specific integrated absorption coefficient for the overtone is 3.5×10^{-5} cm^{-1} per cm path per Amagat^2 at 80°K and 6.2×10^{-5} at 300°K; for the fundamental it is 1.1×10^{-3} cm^{-1} per cm path per Amagat^2 at 80°K and 2.5×10^{-3} at 300°K. The specific absorption coefficient for the overtone plotted against wave number is shown in Fig. 1 for both temperatures. The low temperature contour shows five distinct components. The frequencies 8080, 8415, and 8645 cm^{-1} are in good agreement with those calculated for the Q, $S(0)$, and $S(1)$ lines of the $v=0$ to $v=2$ transition using the constants of the free molecule.[5] The frequencies 8320, 8645, and 8865 cm^{-1}, marked Q', $S'(0)$, and $S'(1)$ in Fig. 1, agree with those calculated using the expression $2\omega_e-4x_e\omega_e$ for the frequency of the Q-branch. The variation in the intensities of the lines as the temperature, and hence the ortho-para ratio, was changed confirms the above assignments. Thus we conclude that the observed absorption is a superposition of two bands. The frequency analysis suggests that the lower frequency band is the first overtone and that the higher frequency band corresponds to a double transition in which both H_2 molecules in the collision undergo the fundamental transition simultaneously. This interpretation is as yet speculative, and is being tested by experiments on the enhancement of the absorption by foreign gases.

An absorption at the overtone frequency of N_2, 4632 cm^{-1}, was observed in a 22.6-cm path of liquid N_2, and in the 30-cm path of the high pressure cell at room temperature with a gas density 81 percent that of the liquid. On the assumption of a density-squared dependence, the specific integrated absorption coefficient in both the liquid and the gas is 1.4×10^{-6} cm^{-1} per cm path per Amagat.[2] The ratio of the specific integrated absorption coefficient of the overtone to that of the fundamental absorption is 1:66. An absorption was also observed in the region of twice the fundamental frequency of the O_2 molecule, 2900–3300 cm^{-1}, using the 85-cm cell at room temperature and O_2 densities up to 134 Amagat. The ratio of overtone to fundamental intensity is 1:30 in this case.

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Photoproton Reactions in Lead

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IN 1946 Baldwin and Klaiber[1] obtained a 4.5-minute thallium activity when lead was irradiated with 100-Mev x-rays. They attributed this to a mixture of 4.76-minute Tl^{207} and 4.23-minute Tl^{206} (at that time incorrectly assigned to Tl^{204}). Any or all of the reactions $Pb^{208}(\gamma, p)Tl^{207}$, $Pb^{207}(\gamma, p)Tl^{206}$, $Pb^{208}(\gamma, d)Tl^{206}$, and $Pb^{208}(\gamma, pn)Tl^{206}$ would produce these activities.

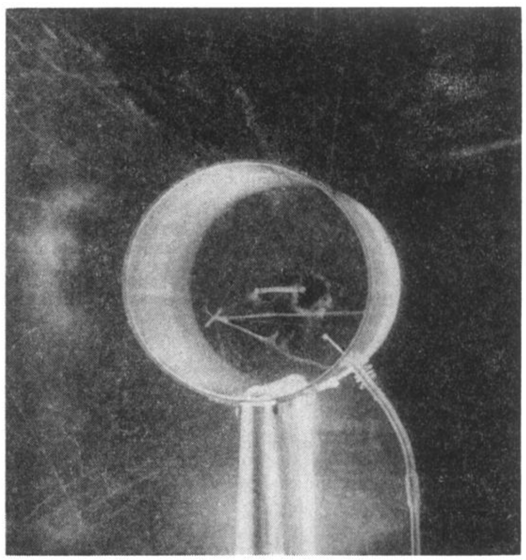

FIG. 2. A neutral particle interacts with an argon nucleus to produce a star in which 11 emitted ionizing particles are visible in the original negative. Protruding through the wall at the lower right is a wire carrying a Po-alpha calibrating source.