Gaussian peaks,[1,4] each of them spreading about (and possibly characterized by) a central, well-defined depth.

These discrete depths coincide with the trap-depths given by the "glow-curves" method, but this last method is not accurate enough to show the existence of distributions around these depths.

The study of the decay at different temperatures gives the same depths, and this provides a direct verification of the above fundamental formula.

This agreement between theory and experiment may be considered as a proof of the monomolecular mechanism involved. Precise experiments are indeed not consistent with the hyperbolic decay law, which is deduced, as is well known, from the assumption of a bimolecular mechanism. However, the derivation of the $1/t^2$ law implies also the assumption that there is a unique trap depth,[5] and the discrepancy may, at first sight, be attributed to this over-simplification. I have shown that for long times of decay the $1/t^2$ law should then be obtained whatever the distribution of traps may be, and so the discrepancy between the results and the bimolecular mechanism is actual.

Thus the experiments are consistent with a monomolecular decay, at least as a first approximation. This may be explained if a great number of traps are situated in the neighborhood of the activator centers. But the existence of photoconductivity and recapture implies the possibility of a more or less important bimolecular perturbation. The above results show that this perturbation is weak during the decay.

If the electrons in the conduction band have high energies, they are not stopped by the defects of the crystal, and in these conditions an approximately bimolecular mechanism is valid; this is the case if excitation or stimulation takes place, or if the electrons are accelerated by an electric field; it may also be the case during the first stage of the decay[6] (10^{-2} sec), when the electrons in the conduction band are coming out of very shallow traps. However, during the long-period phosphorescence caused by the release of electrons from deeper traps, the conduction electrons have very low energies because of the need of a thermal activation (wave mechanical calculations[7] show that these energies are less than kT). They cannot then go far from the traps, and they often fall into the next center, in agreement with an approximately monomolecular decay.

Even in this case of monomolecular decay, however, retrapping takes place if different traps are situated around the same center; the possibility of a bimolecular perturbation also involves recapture. I have studied theoretically the way in which the decay depends on this phenomenon. Analogies appear between the refilling of shallow traps by electrons escaped from deeper traps, and chains of successive radioactive disintegrations. For instance, the quick decay of the glow curves obtained when the time elapsed after the end of the excitation increased is *not* an evidence against recapture, exactly as the activity of a mixture containing comparable weights of radium and radon decreases first with the period of radon (not of radium), and this is not a proof that radium disintegration does not produce radon.

Experiments show indeed that recapture takes place during spontaneous decay[8]; but the phenomenon is found to be much more important under infrared stimulation,[9] and the better the crystallization, the more pronounced is the phenomenon, in agreement with the views expressed above.

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Formation of the *D* Layer

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Of the several processes suggested for the formation of the *D* layer, the following appear to have the strongest support:

$$O_2+h\nu\ (900\text{–}1000\text{A, spectral region } A)\rightarrow O_2^{+}+e, \qquad (A)$$

$$NO+h\nu\ (1100\text{–}1300\text{A, spectral region } B)\rightarrow NO^{+}+e. \qquad (B)$$

Recently, Mitra[1] has reported a detailed calculation to show that the *D* layer is produced by process *A*, which was originally proposed by Mitra, Bhar, and Ghosh.[2] On the other hand, Bates and Seaton,[3] after examining various processes, have shown that the *D* layer may very well be formed primarily by process *B*, which was suggested earlier by Nicolet.[4]

Spectroscopic data seem to show that the *D* layer cannot be produced chiefly by process *A*. As pointed out by Bates,[3] spectrograms by Hopfield[5] show that a 4-mm layer of air completely absorbs radiation in spectral region *A*. Tanaka,[6] who used higher dispersion, confirms Hopfield's results and estimates from pressures used that the windows in region *A* are about two orders of magnitude less transparent than those in region *B*.

Using a vacuum monochromator and photoelectric detection, absorption cross sections of O_2 were obtained[7] in the spectral region 1050–1900A. These data, partly reproduced in Fig. 1, show that the absorption cross sections of the oxygen windows in the region 1100–1250A are about 10^{-20} cm². Moreover, the absorption cross section for the continuum just below 1100A is about 10^{-19} cm², and should be still higher in region *A* on the basis of the data obtained by Hopfield and Tanaka. A reasonable value for air in the spectral region *A* would be 10^{-19} cm² rather than $10^{-20}-5\times10^{-22}$ which were used by Mitra.[1] If the higher value is accepted, process *A* would be placed in the lower *E* layer.

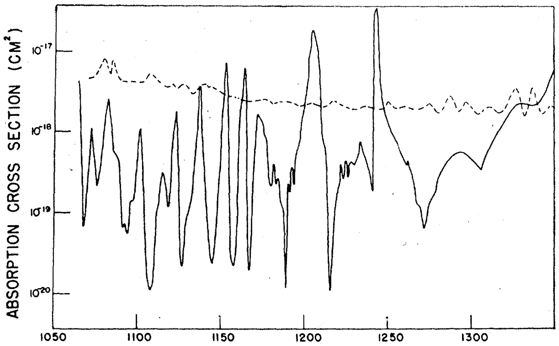

Fig. 1. The absorption cross sections of molecular oxygen (solid curve) and nitric oxide (dashed curve).

In contrast, process *B* has the very attractive feature that NO can be ionized by Lyman alpha which has now been observed[8] in the *D* layer as a strong, solar emission line. However, the concentration of atmospheric NO is not known. If the tentative estimate made by Bates[3] from a rocket spectrogram[9] is the correct order of magnitude, our absorption data for NO seem to indicate that the major part of the production of *D* layer can be attributed to process *B*.

Using NO samples (impurity less than 0.1 percent), the absorption intensity of this gas was measured[10] in the region 1070–2300A. A moderately strong absorption continuum was found in the region below 1400A. The absorption cross section is shown in Fig. 1 by the relatively flat curve, a continuum with a number of weak diffuse bands.

A preliminary photoionization experiment using a vacuum monochromator showed that the ionization current appeared

TABLE I. Absorption cross sections (in cm²) of several atmospheric gases at Lyman alpha.

Gas	Value by Preston	Our value
N_2	$<2.0 \times 10^{-22}$	$<3.0 \times 10^{-22}$
O_2	1.04×10^{-20}	1.0×10^{-20}
CO_2	7.5×10^{-20}	7.3×10^{-20}
H_2O	1.45×10^{-17}	1.44×10^{-17}
O_3		2.4×10^{-17}
CH_4		1.78×10^{-17}
NO		2.5×10^{-18}
N_2O		2.4×10^{-18}
NH_3		7.1×10^{-18}

abruptly at 1345A or 9.20 ev. Rather high yield was obtained over the entire region down to 1070A. Even with narrow slits (0.05 mm) giving a band width of 0.85A the ion current was as high as 5×10^{-11} amp (at Lyman alpha). From the light-intensity measurement based on previous thermocouple data,[11] it was found that photoionization accounted for about fifty percent of the total absorption at Lyman alpha. Thus, the ionization cross section for NO is about twenty-five times larger than the estimated value.[3]

The width and the transparency of the oxygen windows in region *B* are such that photons of required energy, particularly Lyman alpha, can penetrate deep into the *D* layer. In anticipation of the importance of Lyman alpha, absorption cross sections of several gases are listed in Table I, together with those obtained by Preston.[12]

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Lyman Alpha-Line Photographed in the Sun's Spectrum*

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MEMBERS of the Physics Department of the University of Colorado at Boulder have succeeded in obtaining a picture of the sun's spectrum from an altitude of over fifty miles above the surface of the earth. By means of precision instruments sufficiently rugged to withstand high acceleration installed in the nose cone of an Aerobee rocket, a film was exposed, and the radiation from the sun in the far ultraviolet was recorded in regions heretofore not photographed. The results of this work were first reported as a post-deadline paper on January 22, 1953 at the Harvard University, Cambridge, Massachusetts meeting of the American Physical Society.

During the past three years a number of physicists at Colorado have been working on a sun-seeking device or pointing control for installation on high altitude rockets. This is an exceedingly complicated electronic and mechanical device to hold an instrument pointing at the sun during the flight of the rocket which may roll and yaw.

On December 12, 1952 an Aerobee rocket was fired from the Holloman Research and Development Center, New Mexico, carrying the University of Colorado pointing control and spectrograph. This is the first instrument of its kind which pointed directly at the sun for a considerable period. An exposure was taken for 28 seconds and a photograph of the sun's spectrum was obtained. Where previously scientists had photographed the spectrum to about 2000A, in this experiment for the first time the radiation in the far ultraviolet emitted by the hydrogen in the sun has been photographed. Much of this radiation is concentrated in a spectrum line at 1216A, namely the Lyman alpha-line. On the day of the flight the solar activity, represented by hot spots or flares, was reported by the Harvard-Colorado High Altitude Laboratory as being slightly above normal.

On the film the Lyman alpha-emission line at 1216A stands out clearly above the background density. A preliminary examination of the film indicates that the width of the line may be approximately six A and that the intensity of the Lyman alpha-emission outside of the earth's atmosphere may be of the order of 0.03 microwatt per square centimeter. A more careful analysis is being made, and the results will be reported in the near future.

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Helium II Film Transport Rates over Various Surfaces*

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THE experimental investigation of the helium II film transport rate over various surfaces, previously reported from this laboratory,[1,2] is now being reviewed and extended. Although the present work is still in progress, a brief summary of certain results appears to merit presentation at this time, especially in view of a recent publication by Chandrasekhar.[3]

The transport rates tabulated below were obtained by means of the capacitor depth gauge method,[1,2] modified to improve the precision of the measurements. In the present arrangement, transport vessel-capacitors were constructed so that a recording potentiometer not only indicates the motion of the liquid level but also registers the time required to empty (or fill) various sections of the transport vessel. This elapsed time, when correlated with the appropriate volume and limiting perimeter, leads directly to a rate determination. Values cited in Table I are taken from smooth curves constructed in most cases from fifty or more individual rate measurements taken at temperatures between the lambda-point and just below 1°K.

TABLE I. Transport rate in cm³/sec-cm $\times 10^5$.

	1.0°	1.2°	1.4°	1.6°	1.8°	2.0°
Lucite	···	12.2	11.6	11.0	8.9	4.7
Machined nickel	···	14.8	14.6	13.8	11.3	6.8
Machined nickel[a]	13.8	13.7	13.4	12.3	9.8	5.7
Pyrex (ordinary)	···	9.6	9.5	9.1	7.4	4.4
Pyrex (precision bore)	11.8	11.6	11.2	10.3	8.3	4.9
Quartz (transparent)	10.4	10.0	9.5	8.6	7.2	4.3
Quartz (translucent)	11.2	10.7	10.0	8.6	7.7	5.0
Machined thorium[b]	···	40.9	39.1	36.1	28.5	15.5
Machined thorium[c]	···	16.5	16.2	14.6	11.5	7.1

[a] After removal from cryostat and reinstallation and measurement three months later.
[b] Averaged over entire vessel.
[c] At bottom of vessel.

The Lucite measurements previously reported were noted as tentative.[1,2] The current data (using the same beaker with a new capacitor depth gauge) duplicates neither the peak of the earlier report nor the maximum noted by Chandrasekhar.[3] Instead the results show a smooth rate-temperature variation whose absolute values are in agreement with the earlier curve omitting the peak.