the same time the number of large changes becomes less. The probable error in the measured azimuth of a single $\Delta\mathbf{I}$ may be set at $\pm 5°$. This was estimated by picking up the $\Delta\mathbf{I}$ from a small rod of the same silicon iron rotated about a transverse axis in the same field and search coils. We know that each $\Delta\mathbf{I}$ in such a specimen must lie very close to its axis of figure. The angular resolving power in the earlier work[1] was not so high as that now attained and we suggest that the results then obtained were inconclusive mainly for this reason.

The work of Sixtus and Tonks[2] affords an explanation for the effect here observed. We suppose that Barkhausen discontinuities are propagated through a considerable volume only if they result in substantial and favorable changes of $\mathbf{H}$ in front of an advancing boundary. Since reversal of magnetization in any domain best meets this condition discontinuities which arise and proceed in this way have the best chance to grow to a size here observable. We have already pointed out that the largest Barkhausen discontinuities here observed may transcend this condition in their later stages.

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[2] K. J. Sixtus and L. Tonks, Phys. Rev. **35**, 1441 (1930); **37**, 930–958 (1931); **39**, 357–358; **42**, 419–435 (1932); L. Tonks and K. J. Sixtus, Phys. Rev. **41**, 539–540 (1932); **43**, 70–80, 931–940 (1933).

The Heat of Dissociation of N_2

The observation[1] of the long sought intercombination band system $A^3\Sigma \rightarrow X^1\Sigma$ in N_2 has made possible a new determination[2] of the energy of dissociation of N_2. This value $D(N_2) = 7.4$ v seems at first glance to be in disagreement with either my[3] electron impact measurements or those of Tate, Smith and Vaughan.[4] This however is not the case. My results were that it requires 8.62 ± 0.02 v to form $N^+ + N$ from N_2^+. The question involved is the determination of the state of excitation of the N^+ and N formed by electron impact. Possible interpretations are listed below, where I.P. represents the energy necessary to form N_2^+ from N_2. The data in the last column are the result of using for I.P. the accurate value 15.65 ± 0.02 v obtained by Tate, Smith and Vaughan[4]

$N^+ + N$	$D(N_2^+)$	$D(N_2)$	$D(N_2)$
$^3P\ ^4S^0$	8.62 v	I.P.—5.86 v	9.79 v
$^1D\ ^4S^0$	6.73	I.P.—7.75	7.90
$^3P\ ^2D^0$	6.25	I.P.—8.23	7.42
$^3P\ ^2P^0$	5.06	I.P.—9.42	6.23
$^1S\ ^4S^0$	4.59	I.P.—9.89	5.76

As already discussed[3] $D(N_2) = 9.79$ v is certainly too great. The last two values, 6.23 v and 5.76 v seem unreasonably low and the decision rests between 7.90 v and 7.42 v. In my paper 7.90 v was chosen because it was in agreement with Birge's[5] extrapolation of the vibration levels of the A' state of N_2^+ obtaining $D(A') = 3.67$ v and $D(N_2^+) = 6.82 \pm 0.1$ v. If the extrapolation of $D(A')$ is too high and can be lowered to 3.1 v, $D(N_2^+)$ becomes 6.25 v and $D(N_2) = 7.42$ v in agreement with Kaplan and with our third possibility listed in the table. However if Birge's estimate of $D(A')$ and Kaplan's value of $D(N_2)$ are both correct, the value of I.P.[4] for N_2 must be incorrect. My results are in agreement with either alternative and cannot discriminate between the two possibilities.

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Princeton, New Jersey,
May 2, 1934.

[1] L. Vegard, Zeits. f. Physik **75**, 43 (1932).
[2] J. Kaplan, Washington Meeting Am. Phys. Soc. 1934, Paper 92. The conclusions presented at the Meeting were different from those contained in the Abstract.
[3] W. Wallace Lozier, Phys. Rev. **44**, 575 (1933).
[4] J. T. Tate, P. T. Smith and A. L. Vaughan, Phys. Rev. **43**, 1054A (1933).
[5] R. T. Birge, *Molecular Spectra and Molecular Structure*, Faraday Society, p. 713 (1929).

A Stable Hydrogen Isotope of Mass Three

The unexpected announcement at the Physical Society meeting last week by Bleakney and his colleagues from Princeton that they had now found evidence that their deuterium samples contain hydrogen atoms of mass three to the extent of a few parts per million, makes it desirable that we place on record the evidence which had led us to announce a similar conclusion in an abstract (on another subject) submitted for the same program.[1] Using the Allison magneto-optic method, Latimer and Young[2] last autumn announced the detection of a mass-three hydrogen isotope in a sample of heavy water, however, without being able to give a quantitative estimate.

The method we used depends on the simple fact, theoretically predicted and already verified by the comparison of proton and deuton ranges in air, that the rate of loss of energy by any high speed hydrogen nucleus of a given velocity projected into a gas (ion-pairs per millimeter path) is approximately the same irrespective of its mass, whereas

[1] Abstract No. 35, Bull. Am. Phys. Soc., April 10, 1934 (Program of the Washington Meeting). The qualifying phrase "but not proof" was inserted in the abstract, not by reason of any uncertainty in our observations or concerning the reality of the effect, but because we feel that adequate scientific proof of the existence of a new isotope cannot be obtained by any one method. We had not found time to verify our result by collision experiments and we wished to forestall the type of emphatic overstatement so usual in press and magazine reports of scientific news.
[2] W. M. Latimer and H. A. Young, Phys. Rev. **44**, 690 (1933).

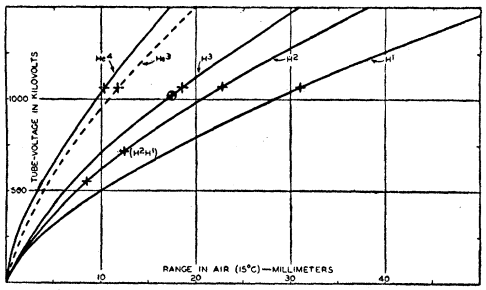

FIG. 1.

the kinetic energy is proportional to its mass. Thus, for the same *initial velocity* the range of a deuton is twice that of a proton, and the range of a mass-three hydrogen nucleus must be expected to be three times that of the proton. Because the focussed beam of million-volt ions from our tube is parallel and highly homogeneous in velocity, and because of the degree of purity of its magnetic resolution, range-measurements on the mass-three spot provided a simple and exceedingly sensitive test for the presence of hydrogen nuclei of mass three, projected without collision from the ion-source at the top of the high-voltage tube.

The range-curve for protons of various energies is marked H^1 in Fig. 1. The range-curve for deutons calculated as above indicated is marked H^2, and has been verified in this and other laboratories during the past two years. The predicted range-curve for hydrogen nuclei of mass three is similarly calculated and marked H^3. Thus with the mass-three spot resolved on to the range-measuring window, we would expect to find protons of energy corresponding to one-third the tube voltage (from H^1 H^1 H^1 and from H^2 H^1), deutons corresponding to two-thirds the tube voltage (from H^2 H^1) and full-voltage H^3 and He^3 nuclei if these exist in the ion-source. Of these possibilities, the H^3 nuclei will have a range considerably in excess of the others (6 millimeters excess at 1100 kilovolts; see crosses, Fig. 1).

Observations last December on the first deuterium introduced into our tube, a sample of heavy water kindly given us a year ago by the late Dr. Washburn, showed the presence of particles having the range expected for full-speed H^3 nuclei.

Arrangements were immediately made to increase the currents in our tube to improve the observations, with the result that our focussing and magnetic resolution were temporarily impaired, and these particles were obscured by a background. Other observations bearing on the stability of the deuton claimed our time and attention until March. Then a repetition of these range measurements with a highly-concentrated H^2 sample, using two copper-foil windows and two mica windows, practically eliminated any possibility that the weak group of range 5 to 6 millimeters beyond the expected deuton value (for 1100 kv H^2 H^1) as found with the mass-three spot might be due to a thin spot in a window, or to soft x-rays or other short "range" spurious effect from the window itself. Disintegration processes known to be occurring in the window (H^2 on H^2) were shown by other measurements to be of far too small a magnitude to affect the electrometer.

With our tube operating at 1100 kilovolts we observed the expected protons from the mass-one spot as a strong purple glow extending out from the window to within a millimeter or two of the expected distance, and measurements with a movable flat ionization-chamber about 2 millimeters deep, connected to an electrometer, showed that the protons have a range of 31 to 32 millimeters. With the mass-two spot similar observations showed the expected 23-millimeter deutons. From neither of these spots was any faint longer-range group in evidence. The mass-three spot showed the expected 12.5-millimeter deutons as a bright purple glow extending about 2 millimeters beyond the window, but in addition a faint purple glow (visible only to the dark-adapted eye) extended beyond this group a distance of 5 or 6 millimeters. The electrometer measurements also showed the presence of a group of maximum range approximately 17.5 millimeters (circle, Fig. 1), as would be predicted for full-speed H^3 nuclei. Assuming the correctness of this identification, from the ionization measured by the electrometer and the current measurements on the various spots we calculated that stable hydrogen atoms of mass three comprised of the order of one part in a million of the particular 98 percent deuterium sample in use during March.

The H^3 nuclei indicated by these observations could not have originated in the high-voltage part of the tube, but must have come directly and without collision from the arc-space of the ion-source, in order to have the spot-position and the range observed. Furthermore, any H^3 formed in the main tube could hardly diffuse back into the ion-source against the pressure-gradient in the probe-canal (1.6 millimeters in diameter and 48 millimeters long). The deuterium flowing through the arc-space was exposed to the 60-volt arc-discharge and the 2000-volt probe-voltage for only a brief time, consequently very few, if any, disintegrations yielding H^3 could be expected in the ion-source itself. Thus the conclusion was reached that the observed proportion of H^3 nuclei must have been present in the dueterium sample as stable H^3 atoms.

We expected shortly to undertake the measurement of the collisions of these particles with protons in a low-pressure cloud-chamber as a final check on their identity; however, the approximate numerical agreement of the Princeton estimate with our own, in which radically different technique and samples from separate sources are used appears to us a satisfactory proof of the existence of H^3 atoms in concentrated deuterium samples.

We are grateful to Professors Urey, Zanetti and La Mer for the deuterium samples used in most of our experiments and to Dr. Brickwedde for whose initial use part of the deuterium was specially prepared.

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