0.01 radian.

An interesting feature of the maser output shown in Fig. 2(b) is the presence of relaxation oscillations, previously also observed in less detail by Collins et al. in ruby. The number of observed spikes decreases rapidly as the power input into the exciting xenon lamp is lowered towards the threshold value until at barely above threshold only a single spike oscillation occurs. Figure 3 illustrates this phenomenon. The single spike takes place at exactly the peak of the pulse output of the xenon lamp, while the multiple spikes begin earlier because the exciting power reaches the threshold value at an earlier point. The spacing between the oscillations increases as the xenon lamp input power is brought closer to threshold. These features seem consistent with the explanation offered by Collins et al. for the relaxation oscillations in the ruby optical maser, perhaps complicated by contributions from several frequency modes within the inhomogeneously broadened line as suggested by G. J. Lasher of this laboratory.

The favorable energy level structure of trivalent uranium as compared to ruby may result in a strong cw infrared source for research purposes in the near future.

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MOBILITY OF HYDROGEN IONS*

Robert N. Varney
Department of Physics, Washington University, St. Louis, Missouri
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Experimental measurements of the drift velocity or mobility of hydrogen ions in the parent gas indicate only a single type of ion, which has consistently been assumed to be H_2^+.[1-3] Rarely, a second ion has been reported,[4,5] but it has always been difficult to observe so that a cloud of suspicion as to its reality has prevailed. Identification of the ion as H^+ seems to be justifiable. The theory of ionic mobilities has been applied by Mason and Vanderslice[6] to hydrogen, and it supports the identification of the ions described above. It predicts also that H_3^+ should be found with a mobility considerably higher than that of either H^+ or H_2^+ or of any observed values reported in references 1-5.

Meanwhile, Stevenson[7] has published some properties of the H_3^+ ion which are listed here:

(1) H_3^+ is formed by the reaction $H_2^+ + H_2 = H_3^+ + H$.

(2) The cross section for this reaction is enormous, approximately 1×10^{-14} cm^2.

(3) The binding energy of H_3^+ is 97 kcal or 4.18 ev (private communication).

(4) H_3^+ ions passing through H_2 gas probably have an enormous charge-exchange cross section, of the same approximate size, 1×10^{-14} cm^2, as for the formation of H_3^+.

(5) The charge-exchange mechanism appears to be an exchange of a proton instead of the more usual exchange of an electron envisaged by the term "charge exchange."

If these findings are correct, and there is every reason to believe they are, then two changes must be made in the theory and interpretation of mobilities of ions in hydrogen.

(1) The H_2^+ ion is never observed in mobility experiments nor will it ever be observed.

(2) The H_3^+ ion has a lower mobility than predicted by Mason and Vanderslice, presumably having the value commonly observed.

The following justifications are offered: The chemical equlibrium constant for the formation reaction for H_3^+ given by Stevenson is so large that there is no possibility of shifting the equilibrium toward the H_2^+ side of the reaction within the bounds of swarm-type experiments, for ex-

ample, by very low pressures. At very high temperatures or very high values of E/p_0, at which equilibrium would be shifted toward the left side, the H_2^+ ion would still not be found as the dissociation of H_2^+ would then prevail. It may be noted that the binding energy of H_2^+ at 2.65 ev is appreciably less than that of H_3^+ quoted as 4.18 ev by Stevenson.

The structure of H_3^+ seems necessarily to be H - H - H. Since H_2 is simply H = H, the exchange of the proton is not surprising. The binding energy of H_2 is very nearly the same as for H_3^+, 4.48 and 4.18 ev, respectively, so that the proton exchange is virtually a resonance phenomenon. The H_3^+ ion passing through H_2 gas is, in effect, the "normal" ion of the parent gas consisting of the parent molecule with an attached proton instead of the parent molecule with a detached electron. The size of the charge-exchange cross section should drastically lower the ionic mobility.

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DISSOCIATION OF H_2^+ AND He^- BY ELECTRIC FIELDS

A. C. Riviere and D. R. Sweetman
United Kingdom Atomic Energy Authority, Aldermaston, Berkshire, England
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Processes leading to the dissociation of molecular ions have assumed some importance recently in connection with injection into thermonuclear devices. In particular, the dissociation of molecular ions by electric fields (or the equivalent $\vec{v}\times\vec{B}$ field), provides an attractive method of injection of high-energy particles which avoids the use of dense low-temperature plasmas or carbon arcs.

Recent theoretical studies by Hiskes et al.[1-3] have shown that the upper vibrational states of molecular ions may dissociate in electric fields of a few hundred kilovolts/cm. In this paper we describe experiments in which this dissociation has been observed and also an experiment in which the He^- ion was dissociated by an electric field.

The experimental arrangement was basically that described by Sweetman[4] for measuring the H_2^+ dissociation cross section in hydrogen. For the present measurements the gas target chamber was replaced by an electrode system so designed that the ion beam would pass through an electric field of known strength. Figure 1 shows the details of the high-field gap and the field distribution as seen by a particle on the axis and on the periphery of the beam. The ions passed through the gap and the high-voltage electrode,

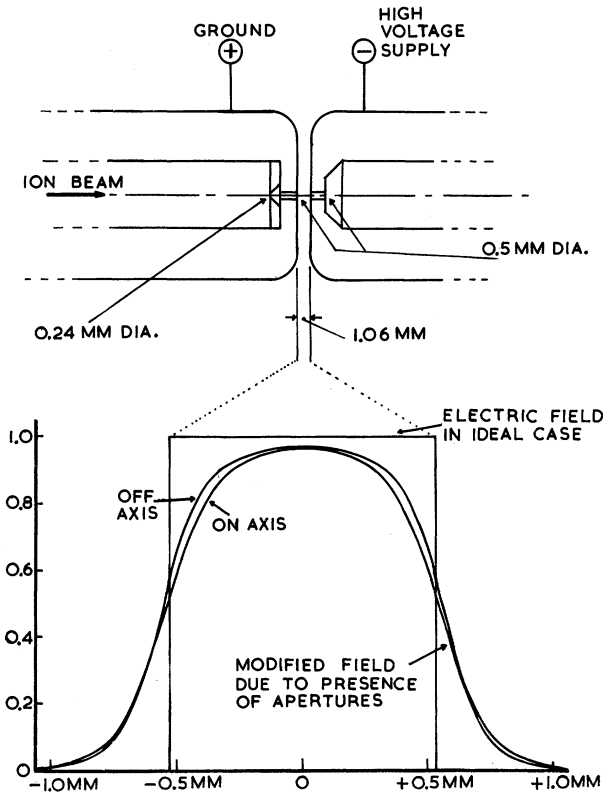

FIG. 1. Details of the high-field gap and electric field distribution.