

correlation was found between the visual structure of the beam observed through the infrared image converter, and the presence of the beats as the angular alignment of the plates was varied. Figure 4(a) shows several beat notes ranging from 50 kc/sec to 2 Mc/sec. Figures 4(b) and 4(c) show the structure of these beats on an expanded scale. It should be noted that in our present system the angular adjustment of the plates is also accompanied by a slight change in plate separation. The important conclusion to be drawn here regards the linewidth of the maser oscillation. As is evident from Figs. 4(b) and 4(c), the beat notes imply linewidths in the range from 10 to 80 kc/sec.

The use of excitation transfer for production of inverted population was suggested^{1,2} by one of the authors. The He-Ne mixture described above is the first gaseous system which has led to maser oscillations at optical frequencies. Recently some evidence for the presence of inverted populations in a Hg-Zn mixture has been reported¹¹ which supports the wide applicability of this principle.^{1,2}

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⁴Not all of the $1s$ levels are truly metastables: the $1s_2$ and $1s_4$ undergo transitions to the ground state; however, due to the trapping of the resonant ultraviolet photons these levels are effectively long-lived and quasi-metastable.

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MASS SPECTROGRAPHIC IDENTIFICATION OF THE ION OBSERVED IN HYDROGEN MOBILITY EXPERIMENTS*

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In a Letter appearing in a recent issue of this journal, Varney¹ pointed out that previous studies of the mobility of ions in pure hydrogen have probably been misinterpreted. In the majority of experiments performed to date, only one ion has been observed, and it has commonly been thought to be H_2^+ . Indications of a second ion, generally assumed to be H^+ , have been seen in a few experiments but the actual existence of this ion remains in doubt. Upon consideration of a study by Stevenson and Schissler² of the cross section for formation of H_3^+ by the reaction $H_2^+ + H_2 \rightarrow H_3^+ + H$, Varney has made the following assertions: (1) The H_2^+ ion is never observed in hydrogen mobility experiments; (2) the ion which in-

variably appears in these experiments is H_3^+ ; (3) it is reasonable to assume that the second ion, if actually present, is H^+ . The purpose of this Letter is to report evidence which tends to corroborate Varney in each of these assertions.

We have recently constructed and put into operation apparatus designed to permit identification of the ions appearing in mobility experiments and to yield information concerning the various types of reactions which can occur at low energy between ions and molecules.³ Ions are produced by electron bombardment inside a long drift tube containing gas at a pressure up to about 700 microns. The ions diffuse down the drift tube under the influence of a weak electric

field. A sample of the ion population at the end of the drift tube is extracted through a two-stage differential pumping chamber and passed into a 60° magnetic deflection mass spectrometer. The number of ion-molecule collisions in the drift tube may be varied over a wide range by changing the source position and/or the gas pressure. Information concerning the nature and probability of the reactions occurring is revealed by the resulting changes in the ionic mass spectrum.

In studies of hydrogen, the three known species (H^+ , H_2^+ , and H_3^+) are all observed at very low drift-tube pressures, p , and for short drift distances, d . The H_3^+ ion is by far the most abundant throughout the range covered. As pd is increased, the abundances of H^+ and H_2^+ relative to that of H_3^+ diminish, the H_2^+ abundance falling off more rapidly than that of H^+ . Taking into account the increasing ion losses due to diffusion, recombination, etc., it appears that the H_3^+ population increases mainly at the expense of H_2^+ . This is consistent with Stevenson and Schissler's finding that the reaction $H_2^+ + H_2 \rightarrow H_3^+ + H$ has a large cross section. The persistence of H^+ ions in our spectrum to higher pd values than that at which H_2^+ disappears indicates that the cross section for the reaction $H^+ + H_2 \rightarrow H_3^+$ is much smaller, consistent with the conclusions of other

investigators.

In mobility experiments, pd is always made rather large in order that a steady state, constant drift velocity be achieved. Values of pd of 10 cm-mm Hg, and higher, are commonly used. At $pd \gtrsim 1.5$, only the H_3^+ ion is seen in our spectrometer. This fact appears to corroborate Varney's first and second assertions. Furthermore, since the H^+ ion persists to much higher pd than does the H_2^+ ion, it seems reasonable to assume that if a second ion is observed, it is H^+ . Of course, the possibility exists that the second ion sometimes reported is an impurity.

A more complete discussion of the work reported here will be presented in another paper which will also contain a detailed description of the apparatus.

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COLLISIONAL DETACHMENT IN MOLECULAR OXYGEN*

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The measurements reported in this Letter show that the electron affinity of the negative ion of molecular oxygen formed in low-energy swarm experiments is 0.46 ± 0.02 ev. This value is three times that used in the analyses of recent photodetachment experiments.¹ In addition, we show that the frequency of electron detachment collisions between oxygen negative ions and a thermal distribution of oxygen or nitrogen molecules in the lower ionosphere is at least two orders of magnitude smaller than the accepted value.² Therefore, a new mechanism for electron detachment must be found in order to explain the appreciable electron densities found in the lower ionosphere at night.

The experimental apparatus used in these

measurements is the same as that used by Chanin, Phelps, and Biondi³ to measure electron attachment coefficients. In the present experiments, either (a) a pulse of voltage is applied to the grid to collect negative ions and electrons in the vicinity of the grid and thus reduce the current reaching the collector in proportion to the sum of electron and negative-ion currents reaching the grid, or (b) a pulse of high-frequency voltage (~ 1 Mc/sec) is used to collect only electrons⁴ and reduce the collector current in proportion to the electron current reaching the grid. The waveforms obtained are shown in Fig. 1. The upper waveform for $T = 423^\circ\text{K}$ shows an initial peak due to electrons which have crossed the tube without attachment. This peak is followed by an exponen-