circumstance nearly obtains at -41°C in 0.14M solution. Since $\mu = 1.5\times10^{-2}$ poise, the bracket becomes

$$[\;] = \mu f_e/(N_\gamma kT) \approx 10^{-1}.$$

The same solution's spectrum at +28°C should again yield the bracket. The exchange-narrowing theory[4] relates the observed width $\delta\nu$ of the single narrowed line to the second moment $\langle\Delta\nu^2\rangle$ of the hyperfine pattern and f_e as

$$\delta\nu \approx \langle\Delta\nu^2\rangle/f_e \,. \tag{6}$$

The value of $\delta\nu$ corresponding to 6.4 gauss and $\langle\Delta\nu^2\rangle$ corresponding to the measured[9] 180 gauss^2 thus fix f_e as about 8×10^7 sec^{-1}. The viscosity of toluene at 28°C and Eq. (5) then yield about 10^{-1} again for the bracket.

Hausser's data on $10^{-3}M$ α,γ-bisdiphenylene β-phenyl allyl in ethanol at 0°C give the bracket a value 2 for that system. Considering the crudeness of our model, including its spherical approximation for aromatic molecules, the bracket values lend credence to the suggested mechanism. If less complicated systems can be found with which to test these ideas, they might merit theoretical refinement.

We wish to thank Mr. John Goldsborough and Professor L. I. Schiff for helpful discussions.

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[7]See Fig. 2 on p. 329 of reference 3. Although the model Anderson calculates is a simplified one, it provides an illustration of the broadening of each fine structure component preliminary to a narrowing of the entire pattern into a single line. As the mean interruption frequency further increases, the single line itself grows narrower.

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DISSOCIATION OF H_2^+ IONS BY HYDROGEN

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Interest in the dissociation of H_2^+ ions by hydrogen and other gases has been stimulated recently by the injection problems of thermonuclear devices and accelerators. In particular, the injection current required for a thermonuclear experiment such as OGRA is critically dependent on the cross section for this process, yet there is a discrepancy of a factor 3 between the values obtained by different workers. In some of this work, the importance of the charge exchange cross section and the cross section for double proton production at energies of about 100 kev does not appear to have been realized and none of the techniques so far used has enabled all these processes to be resolved.

In the present work, the cross sections for the four processes contributing significantly to loss of the H_2^+ ions are separately determined. These processes are:

$$H_2^+ \rightarrow H^0 + H^+, \tag{1}$$

$$H_2^+ \rightarrow H^+ + H^+ + e, \tag{2}$$

$$H_2^+ \rightarrow H^0 + H^0 - e, \tag{3}$$

$$H_2^+ \rightarrow H_2^0 - e, \tag{4}$$

with cross sections σ_1 to σ_4, respectively.

H_2^+ ions accelerated in a 3-Mv Van de Graaff machine were passed through a differentially pumped gas chamber. The beams of neutral particles, H_2^+ ions, and protons were then separated by a magnetic field and detected by 1-in. CsI crystals mounted on photomultiplier tubes. The entry of two protons simultaneously into the crystal from process (2) was recorded as a pulse of double the height of that from a single proton [process (1)]. Similarly processes (3) and (4) produced pulses in the neutral particle counter of double the height of those due to neutral particles from process (1). By differential discrimination of the output from the crystals it was possible to separate very clearly double from single events and hence the partial cross sections for the processes (1), (2), and (3) + (4).

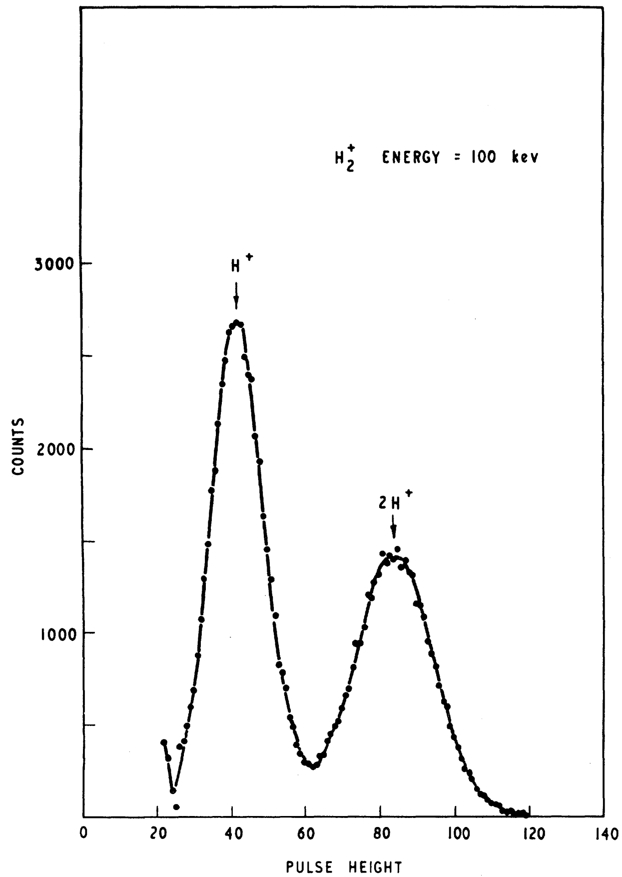

FIG. 1. Pulse-height distribution in proton counter for 100-kev H_2^+ energy. The upper peak represents the two protons from process (2) entering the crystal simultaneously.

Figure 1 shows the pulse-height distribution from the proton counter at 100-kev H_2^+ energy. At higher energies the groups were clearly separated and the peak to valley ratio was about 200:1.

In order to separate (3) from (4) a separate experiment was performed with a narrow slit (0.148 mm across) mounted in front of the neutral-particle detector. The width of the slit was such that the probability of both of the H^0 particles from process (3) entering the crystal was negligible. Under these conditions, the double-height pulses corresponded only to H_2^0 particles from process (4). The slit was moved across the beam and the count rate plotted against position for a given count on the H^+ counter. Integration of the resulting curves gave the cross section for H_2^0 production. In the energy range 100 - 200 kev it was found to be equal to about 30% of $\sigma_3 + \sigma_4$. Good agreement was obtained between total neutral particle counts with and without the slit.

The partial cross section results are shown in Fig. 2. It is seen that the partial cross section

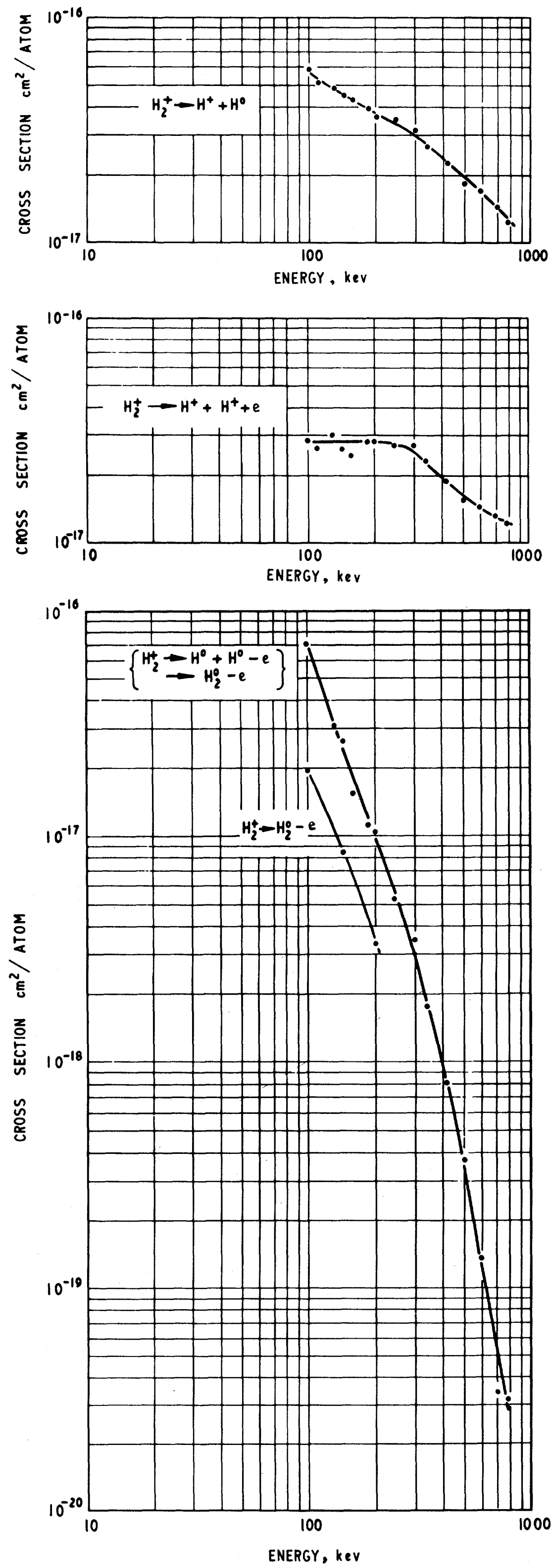

FIG. 2. Partial cross sections for dissociation of H_2^+ into H^0+H^+, $2H^+$, $2H^0$, and H_2^0 plotted against H_2^+ energy. The fraction of the total double neutral particle production remaining as H_2^0 is indicated.

for double proton production is important at all energies and is a slowly varying function as would be expected for excitation to the repulsive double proton state. The partial cross section for double neutral particle production is important at low energies and is a strong function of energy, consistent with a charge exchange mechanism. The angular distribution of the H^0 particles from process (3) is narrower than that from process (1) indicating that process (3) proceeds by charge exchange followed by breakup of 70% of the H_2^0 particles by excitation to the $1\,^3\Sigma_u$ repulsive state.

The total cross section for loss of H_2^+ ions is plotted in Fig. 3 together with the results of other workers. The results of Damodaran[1] may be compared directly with ours and are about 30% higher, as are also those of Barnett[2] at high energies. The low-energy cross sections of Barnett were defined on the assumption that the cross sections for processes other than simple dissociation were small. In view of the large value of these at low energies it is not easy to compare the results directly. However, if in Barnett's work only a small fraction of the particles were dissociated then the cross sections should approximate to those for proton production. These are plotted in Fig. 3 where it is seen that his results are a factor of 1.8 lower than ours. Comparison with the results of Fedorenko[3,4] is not possible until the details of the experimental measurements are known but their cross sections would appear to be somewhat larger than ours.

The principal source of error in the measurements reported here is in reading the pressure in the gas chamber. It is estimated that the results are accurate to ±10% in absolute value.

The author is extremely indebted to Mr. R. E. Bradford for his work in designing the apparatus and taking the results, and to Dr. K. W. Allen for stimulating discussions.

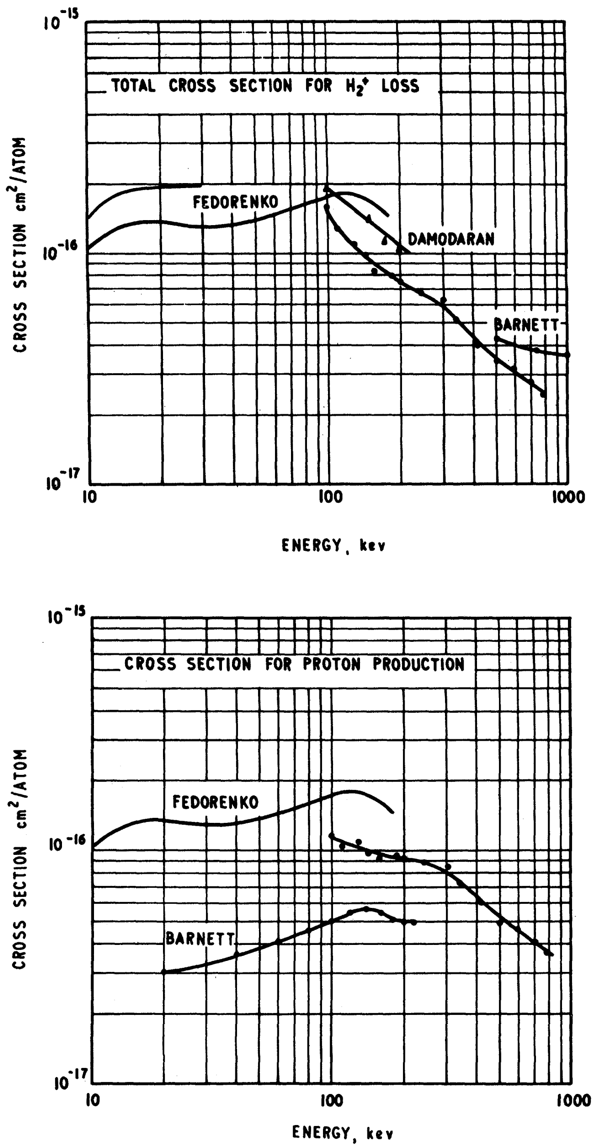

FIG. 3. Total cross section for H_2^+ loss and cross sections for proton production $(\sigma_1 + \sigma_2)$ plotted against H_2^+ energy.

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