the signal-to-noise ratio also should allow studies of collision broadening and of Zeeman and Stark effects in the microwave spectrum.

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ELECTRON DETACHMENT FROM NEUTRAL HYDROGEN BY A MAGNETIC FIELD*

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A hydrogen atom traversing a magnetic field $\vec{B}$ with velocity $\vec{v}$ experiences a force that can lead to electron detachment, $H^0 \rightarrow H^+ + e^-$. The manner in which the breakup probability increases with increasing values of $\vec{v}\times\vec{B}$ and with initial atomic excitation has been discussed by Hiskes,[1] and Hiskes and Sweetman[2] have considered the possible application of this process in the creation of high-temperature plasmas. Fast neutral beams of hydrogen atoms in excited states can be produced by charge exchange or, with more latitude in particle energy, by gas-collisional breakup of molecular ions. This paper describes the measurement of magnetic-field electron detachment from hydrogen atoms produced by the latter process.

The experimental arrangement is shown in Fig. 1. H_2^+ ions were accelerated to 20 MeV in the Berkeley heavy-ion linear accelerator, and were partially dissociated in a gas cell. The parallel $\frac{3}{16}$-in. diameter fast neutral beam produced was passed through a sweeping magnet to remove the charged particles (H^+ and undissociated H_2^+). These charged particles were deflected onto a beam-monitoring probe. No further collimation of the neutral beam was necessary, and as a result breakup at slit edges was not a problem. The electron detachment and particle analysis were carried out in a dc magnet with a 4-in. gap and a maximum magnetic field of 12 kilogauss. The gap in the first 1.5 in. of the magnet could be reduced to 1 in., thereby producing a maximum field of 19 kG.

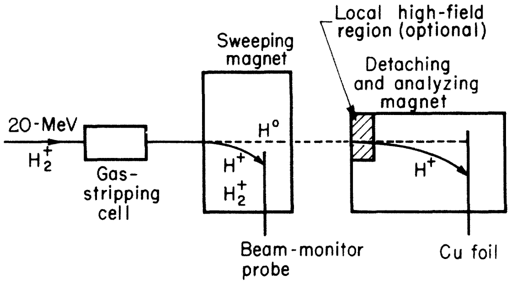

FIG. 1. The experimental arrangement (not to scale).

Analysis was performed by activating 0.010-in.-thick Cu foils placed in the analyzing magnet perpendicular to the direction of the incident beam. The spatial distribution and the relative intensities of the H^0 and H^+ currents were determined by counting the Zn^{63} activity ($T_{1/2} = 38$ min) produced in the foils. This technique has been described previously by us.[3] Two or more experimental bombardments were made at each magnetic field, and in all cases the results were statistically consistent.

The results are shown in Fig. 2. Two gases

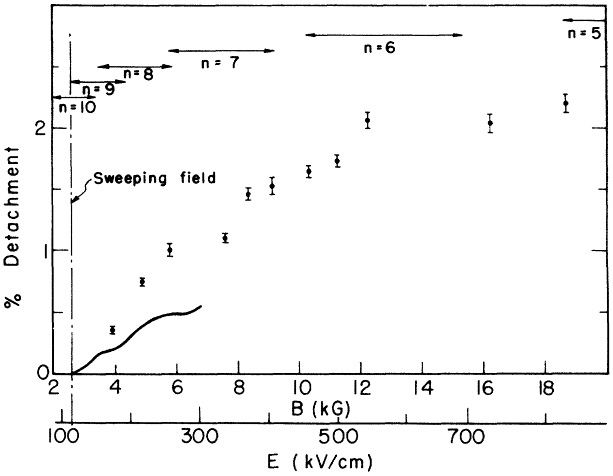

FIG. 2. Fractional electron detachment vs magnetic and equivalent electric fields. The electric-field detachment of 200-keV H^0 from charge exchange (reference 3) is shown as a smooth curve. (In our experiment, all neutrals that can be stripped by a magnetic field of 2.55 kG are ionized in the sweeping field. For this comparison, therefore, we have subtracted from the data of reference 3 a number equal to the detachment at the equivalent electric field, 120 kV/cm, namely, 0.65%.)

were used in the gas stripping cell: Ar and H_2. Unfortunately, the pressure in the external Hilac vacuum system is so high that even with auxiliary pumping the molecular dissociation in the 30-ft-long vacuum pipe accounted for more than one third of the maximum neutral beam that was obtained by optimizing the gas pressure in the 20-cm-long stripping cell. The nature of the background gas is unknown. The fractional detachment of neutrals produced by stripping in argon, hydrogen, and background gas is statistically the same, and only the argon data points are shown in the figure. A background fractional detachment of 0.35 ± 0.02, due to breakup of the neutrals on the residual gas, has been subtracted from the raw data. This background was obtained by raising the magnetic field in the sweeping magnet to a value considerably greater than the field in the detachment and analyzing magnet. Under these conditions all observed breakup was assumed to be due to the residual gas.

The abscissa in Fig. 2 is given in two sets of units: the magnetic field in the detachment magnet and the equivalent electric field, $\vec{E} = \vec{v} \times \vec{B}$, in the particle rest frame. We have indicated on the figure the magnetic field in the sweeping magnet. States that detach below this field value are inaccessible to our analysis, since they are detached by the sweeping magnet. The fields at which atoms with a principal quantum number n should be appreciably dissociated in a time appropriate to our experiment (approximately 5×10^{-10} sec) are shown at the top of Fig. 2. The indicated spread in field for each principal quantum number is due to the different detachment thresholds for the range of quantum numbers belonging to a principal quantum number n. Also shown as a smooth curve are the adjusted electric-field detachment data of Sweetman,[2] obtained with 200-keV neutrals produced by charge exchange.

The data below 12 kilogauss were obtained with the 4-in. magnet gap, those above with the 1-in. gap. Although there is a small region of field overlap for the two geometries, it is possible that the break in the detachment curve at 12 kG ($n = 6$?) may be affected by the change in field shape.

It is interesting that the fractional detachment in this experiment is (a) large and (b) similar to the charge-exchange results of Sweetman. The latter fact is not entirely unexpected, because Hiskes has recently calculated that the excitation distribution of neutrals from gas collisional breakup at energies above a few hundred keV should be similar to the excitation from charge exchange.[4] He has also suggested[5] that in both experiments the final excitation distribution of the H^0 may be determined chiefly by secondary excitation collisions of the neutral atoms in the charge-exchange or stripping cells, rather than by the production process.

The $\vec{v} \times \vec{B}$ ionization of 30-keV H^0 produced by the gas breakup of H_3^+ ions has been observed by Sweetman. At such low energies, however, it is likely that a considerable fraction of the emergent neutrals is in fact the result of charge exchange of protons produced by H_3^+ collisions in the gas cell. At the high energies of our experiment this possibility does not exist.

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