VI. MOLECULAR BEAM RESEARCH

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A. CHLORINE EXPERIMENT

The hyperfine structure of the $^2P_{3/2}$ - $^2P_{1/2}$ fine structure doublet in Cl^{35} and Cl^{37} has been measured and the ratios of the magnetic dipole interaction constants, $a^{35}_{1/2}/a^{37}_{1/2}$ and $a^{35}_{3/2}/a^{37}_{3/2}$, are found to be in excellent agreement with the values obtained from nuclear induction measurements. Measurement of the low frequency transitions in the $^2P_{1/2}$ state of Cl^{35} and Cl^{37} in a magnetic field calibrated by using an appropriate transition in Cs^{133} has given a value of the anomalous spin gyromagnetic ratio g_s for the electron in agreement with previous theoretical and experimental work.

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B. SURFACE IONIZATION OF HALOGENS

Experiments are under way to study the phenomenon of surface ionization of the halogens and the application of the process to the detection of atomic and molecular beams. Ionization by this method is possible in principle since the electron affinities of the halogens range from 3.20 volts for iodine to 4.12 volts for fluorine. When such atoms strike the surface of a metal (in our case a heated wire) whose potential barrier for electrons is less than the electron affinity of the halogen, an electron may be given up to the atom to form a negative ion. Such ions, after passing through a mass spectrometer, are then detectable by either an electron multiplier or a Faraday cage and FP 54 amplifier.

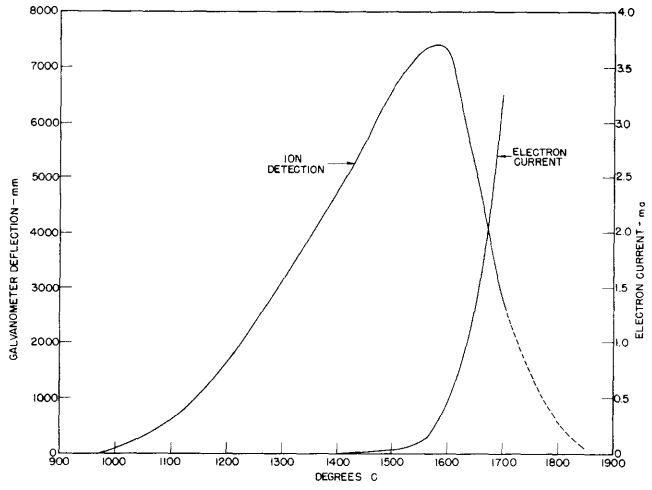

Fig. VI-1

Variation with temperature of detection efficiency of chlorine atoms and electron emission from 40-mil tungsten ribbon ionizer.

The ionization efficiency of chlorine on the surface of several tungsten and thoriated tungsten wires under varying temperatures has been investigated and has led to the following results:

1. A maximum was found in the ion formation efficiency at the temperature where the electron current

from the ionizing wire became appreciable (see typical curve, Fig. VI-1). The peak was attributed to the presence of the electron emission or space charge rather than a thermal dissociation of the ion (P. Kusch: Lecture Notes on Molecular Beams, p. 85, Columbia University, 1950) since it occurred approximately 400°C higher in pure tungsten (1600°C) than in thoriated tungsten. The thermionic emission from tungsten at the temperatures used is at least an order of magnitude less than that from thoriated tungsten.

2. The negative ion formation is at least ten times more efficient with thoriated tungsten (work function 2.6 volts) than with pure tungsten (work function 4.52 volts). This is an expected result as the probability of ionization increases with the difference between the electron affinity of the atom and the work function of the ionizer.

3. The ratio of beam to background of chlorine from the heated wire was found to lie between about 0.25 to 0.7 for the samples of thoriated tungsten tested, while for the pure tungsten wire this ratio was found to be over 7. A low background is necessary if the counting of the ions is to be done with an electron multiplier.

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