VI. MOLECULAR BEAM RESEARCH

Prof. J. R. Zacharias
Prof. B. T. Feld
Dr. B. Bederson
Dr. V. Jaccarino
A. G. Bousquet
J. H. Holloway
J. G. King
H. H. Stroke

A. PRECISION MEASUREMENT OF THE HFS OF RB^{87}

The second atomic beam apparatus was used to obtain a high precision measurement of the hfs of $Rb^{87}(\Delta\nu)$. The field independent transition $F = 2,\ m_F = 0 \leftrightarrow F = 1,\ m_F = 0$ was observed at a frequency of approximately 6835 Mc/sec, which yields $\Delta\nu$ directly except for a small correction due to the applied field (~ 0.4 gauss). The correction is -275 cps.

The transition region was confined to a small section of a waveguide in which the TE_{01} mode was excited by means of a Raytheon 5721 reflex klystron. Two slits cut parallel to the axis of the waveguide allowed the beam to travel through the transition region.

Part of the power of the 5721 was mixed with the forty-fifth harmonic of 150 Mc/sec, produced by a 5 Mc/sec crystal. The crystal was constantly compared to WWV's signal. A small added frequency of about 84 Mc/sec was obtained by adding the second harmonic of a G. R. 805C oscillator to 45×150 Mc/sec to give the exact monitoring frequency against which the 5721 frequency was compared. By using additional voltage stabilization and filtering on the klystron power supply, it was possible to stabilize the klystron so that its frequency could be kept to within 0.5 kc/sec of the monitoring frequency for the time necessary to obtain a resonance measurement.

The result of nine independent runs yields a (corrected) value of

$$\Delta\nu(Rb^{87}) = 6834.7005 \pm 0.0014$$

where the quoted error is the average deviation of the nine runs.

B. Bederson, V. Jaccarino

B. DETECTION TECHNIQUES

1. Surface Ionization of the Halogens

Experiments were performed to obtain the efficiencies of negative ion formation on metallic surfaces. The temperature dependence of the ion formation was described in the Quarterly Progress Report, October 15, 1951. The reduced efficiency at high temperatures was attributed to ionization of the incoming molecules by electron collisions, in addition to field distortions by the space charge in the ionizer. The former cause was found by observing the ionization efficiency at constant temperature and varying the field strength in the ionizer. The probability of ionization of the beam was greatest at very low accelerating voltages, while the number of background ions was found to be independent of voltage over a wide range. The results follow:

a) The efficiency of negative ion formation of chlorine on thoriated tungsten was found to be 1 in 10^4.

b) The ratio of detection efficiency of chlorine to iodine was found to be approximately 70, chlorine to bromine 14, and chlorine to fluorine less than one half.

c) Up to the maximum efficiency of negative ion formation, the Langmuir-Saha theory (predicting an efficiency variation as $e^{(\phi - W)/kT}$, where ϕ is the electron affinity of the halogen, W is the work function of the hot wire metallic surface, k is the Boltzmann constant, T is the absolute temperature) was found to be correct for the temperature dependence and the ratios quoted above, but not for the absolute ionization efficiency. The discrepancy for the latter is implied by the causes of the shape of the temperature vs the ion formation efficiency curve. These results are to be compared with those of J. W. Trischka et al (J. W. Trischka, D. T. F. Marple, A. White: Phys. Rev. 85, 136, 1952).

H. H. Stroke

C. THE SPIN GYROMAGNETIC RATIO OF THE ELECTRON

The anomalous spin gyromagnetic ratio of the electron has been obtained from observations of the Zeeman effect of the hfs interaction in the $P_{3/2}$ and $P_{1/2}$ states of atomic Cl^{35}.

The experimentally determined quantities are the atomic g_J values where g_J may be written in the symmetric form

$$g_J = \frac{g_L + g_S}{2} + \frac{g_L - g_S}{2} \frac{L(L+1) - S(S+1)}{J(J+1)} .$$

Using the facts that L = 1, S = 1/2, and J = 3/2 for the $P_{3/2}$ state and L = 1, S = 1/2, and J = 1/2 for the $P_{1/2}$ state and assuming that $g_L \equiv 1$, we have

$$g_S = \frac{4K - 2}{1 + K}$$

where K is the experimentally measured ratio

$$K = \frac{g_{J = 3/2}}{g_{J = 1/2}} .$$

The average of eight independent measurements in fields up to 500 gauss produces a value of $g_S = 2(1.00121 \pm 0.00010)$.

This deviation of g_S from the value of 2 predicted by the Dirac theory is in agreement with experimental results on the alkalis and hydrogen and has been quantitatively accounted for theoretically by Schwinger. The results testify to the validity of Russel-Saunders coupling for the case of a closed shell minus an electron in chlorine.

Further work is in progress to increase the experimental accuracy of this measurement.

J. G. King, V. Jaccarino