IV. MICROWAVE SPECTROSCOPY

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A. MOLECULAR-BEAM MICROWAVE SPECTROSCOPE

A source for generation of an alkali halide beam for use in the molecular-beam microwave spectroscope was developed and tested. The beam intensity was found to be 5.5×10^{14} molecules per second for a source of dimensions 0.375 inch × 4 inches. The source is so designed that 8 equal source units in parallel can be used, thus permitting a beam strength of 4.4×10^{15} molecules per second. The beam strength was measured with a surface ionization detector. A condensation target was utilized for studies of beam collimation. In Fig. IV-1 we see two cross sections through the beam. The dark (dotted) rings correspond to a given amount of beam material deposited. On the right-hand side, two rings (R) appear, indicating an uneven beam distribution. On the left-hand side, only one ring (R) is found, indicating better collimation.

M. Peter

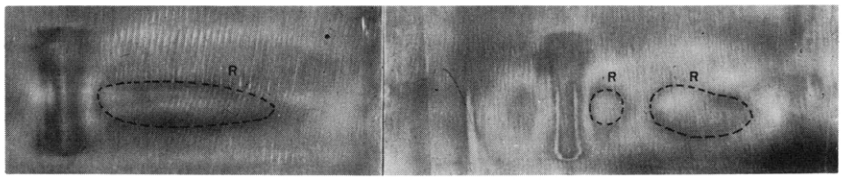

Fig. IV-1. Study of alkali-halide beam collimation.

B. PARAMAGNETIC RESONANCE

The paramagnetic resonance spectrograph, described in the Quarterly Progress Report of April 15, 1956, was applied to the study of the free oxygen atom. The ground state of the oxygen atom is a ^3P state and, therefore, is paramagnetic. The detected absorption is an unresolved triplet that arises from Zeeman transitions between different magnetic quantum states of the $^3P_1$ and $^3P_2$ configurations. Satellite lines on either side of the main absorption were observed. The measured g-factor is in agreement with previously published results of Rawson and Beringer (1). Figure IV-2 shows the first derivative of the absorption line as a function of dc magnetic field.

Oxygen in the atomic state is produced in a microwave gas discharge. The discharge takes place in a quartz tube placed axially in the X-band cylindrical microwave cavity. The discharge is activated by a 10-cm cw magnetron which feeds through a 0.875-inch

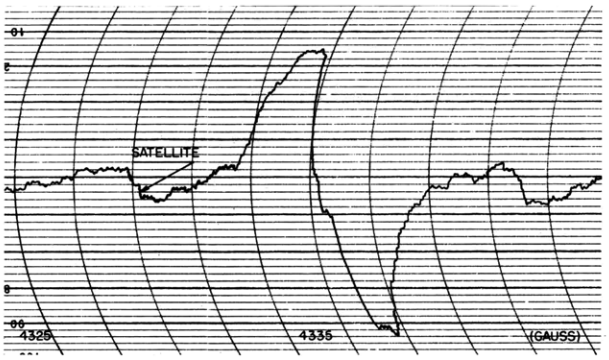

Fig. IV-2. Paramagnetic resonance in the ^3P ground state of atomic oxygen.

coaxial line. The coaxial line is terminated at one end by the cavity and the quartz tube. The discharge begins at this termination point and extends over the entire length of the cavity. This ensures that all evanescent products of the discharge are present in the cavity. This method is, therefore, useful for studying a wide variety of evanescent paramagnetic substances.

Further work on this problem continues.

G. J. Wolga

References

1. E. B. Rawson and R. Beringer, Phys. Rev. 88, 677 (1952).

C. MICROWAVE FREQUENCY MEASUREMENT

To provide design information for microwave frequency measurement, a study of crystal mixers and harmonic generators was carried out. Microwave frequencies are measured by beating a sample of the microwave signal against a harmonic of a known uhf signal, the harmonic generation and mixing being performed in a single crystal. The beat frequency is amplified in an i-f amplifier tuned to some convenient known frequency. In our applications, the microwave frequency is swept; therefore, the detected i-f output will appear as a pip. To conveniently resolve this pip from noise, the i-f input should be in excess of 100 μv.

The beat-frequency output of the crystal is found to be a function of: the incident microwave power, the uhf power, the order of the harmonic generated in the crystal, and the particular crystal. The last factor is of no great concern, since, by varying the microwave and uhf power to produce an optimum output pip, most new 1N26 crystals could be made to perform within a factor of three or four. In general, the ideal

microwave input is in the vicinity of 20 μa of rectified power. The uhf power should not fall much below 15 ma.

The effect of harmonic order is rather strong. The pip amplitude decreases approximately exponentially with increasing harmonic order. If 100 μv is used as the criterion for the minimum acceptable i-f input, the harmonic order should not exceed 50.

S. Krongelb

D. MICROMODULATOR

A system (micromodulator) is being constructed for measurement of the absolute intensity of a microwave absorption signal that occurs at any frequency. The apparatus employs the strong, narrow (approximately 2 gauss half-width) paramagnetic resonance in crystals of POV (diphenyl trinitrophenyl hydrazil). This substance is an organic free radical, and in a magnetic field, H, the two possible spin orientations of its odd electron give rise to a Zeeman splitting of the ground-state energy level. The frequency separation of the splitting is $\nu = (2.8)$ H. Fields of 3300-15,000 gauss produce separations of 9000-42,000 mc. Hence, by passing microwave radiation of arbitrary frequency through the POV crystals and properly adjusting H, absorptive transitions can be induced from the lower to the upper Zeeman level. By calculating the matrix element for the transition, it is possible to compute the absolute strength of the POV absorption. By displaying it at the same frequency as that of the unknown line, it can be used as a standard for determining the absolute intensity of the unknown signal.

The apparatus consists of a section of waveguide, tapered in one dimension, that is placed between the poles of an electromagnet, with the POV crystals held in the center of the section. Small coils around the magnet poles, driven in synchronism with the spectrometer's regular Stark-field generator, modulate the microwave that carries the absorption signal. This signal is detected by a 1N23 crystal; then it is passed through a spectrometer amplifier which is followed by a phase detector. The POV absorption (or, more precisely its derivative) is displayed either on an oscilloscope or an Esterline-Angus recorder. The device is portable and it can be inserted in series with any apparatus that is being used for measuring an unknown. Field inhomogeneity, causing undue broadening of the resonance line, is the principal problem thus far; it is expected that compensating coils on the magnet poles will eliminate this difficulty.

R. D. Mattuck