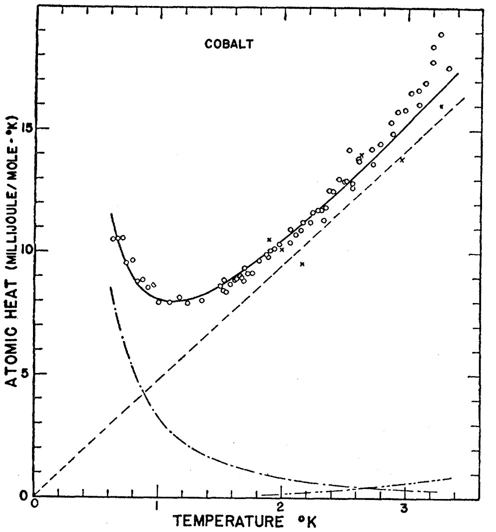

FIG. 2. Atomic heat of cobalt metal. × Duykaerts' values. The solid line (——) is the sum of the lattice specific heat (—–––—), the electronic specific heat (———), and the nuclear specific heat (—–—–).

=0.0175°K is comparable in magnitude with the cobalt salts in which the hyperfine splitting is believed to be predominantly due to the orbital moment of the 3*d* electrons.[7] It is of interest to note that the ratio of the hyperfine interaction to the magnetic moment is remarkably alike for the bulk metal and the ionic compounds as is shown in Table I. This suggests that even in the metal the predominant interaction is between the nucleus and the 3*d* electrons.

Modifications are now being made on the apparatus which will permit the measurements to be extended to considerably lower temperatures, ~0.3°K; and will at the same time allow for a more reliable calibration of the resistance thermometers in the region below 1°K.

We wish to acknowledge the assistance of Mr. J. S. Stroud in the development of the magnetic refrigerator-calorimeter system, the grant from the Ohio State University Development Fund for the construction of the apparatus, and the National Science Foundation for funds for personnel during the period of this investigation.

TABLE I. Hyperfine coupling data for cobalt and cobalt salts.

Material	CT^2/R	A/k (°K)	μ/β	$A\beta/\mu k$ (°K)
Cobalt metal	4.0×10^{-4}	1.75×10^{-2}	1.71[c]	1.02×10^{-2}
Cobalt ammonium sulfate	16.0×10^{-4} [a]	3.52×10^{-2} [b]	3.22[d]	1.09×10^{-2}
Cobalt potassium sulfate	25.1×10^{-4} [b]	4.11×10^{-2} [b]	3.28[d]	1.25×10^{-2}
Cobalt fluosilicate	10.1×10^{-4} [b]	2.64×10^{-2} [b]	2.91[d]	0.91×10^{-2}
Cobalt sulfate (dilute)	18.0×10^{-4} [b]	3.65×10^{-2} [b]	3.45[d]	1.06×10^{-2}

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Quenching of the Negative Glow by Microwaves in Cold-Cathode Gaseous Discharges

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QUENCHING of the afterglow of an interrupted electrical gaseous discharge by the application of microwaves or dc fields to the decaying plasma has been reported.[1,2] It is presumed that the effect results from a reduction in the rate of volume recombination of positive ions and electrons, brought about by elevation of the mean electron energy in the presence of the field.

In present experiments a quenching by microwaves of the visible radiation from the negative glow region of a cold-cathode dc discharge has been observed, and preliminary results indicate the usefulness of the effect in a study of fundamental plasma processes. In particular, the possibility of separation of the fraction of emitted radiation due to a recombination process from that due to direct excitation provides a new experimental approach toward resolution of the long-standing controversy[3] concerning the mechanism for population of excited states.

A cold-cathode discharge, confined to a 0.4-inch i.d. Pyrex tube, was established by a 500-microsecond dc excitation pulse in the center of an RG 52/U wave guide with the lower and upper inner surfaces of the wave guide as cathode and anode. The microwave field was measured to be reasonably uniform throughout the enclosure of the Pyrex tube. Radiation emitted from the discharge and appropriate to the experiment was detected through the side of the wave guide by a type 6217 photomultiplier in such a manner that approximately 0.025-inch resolution was obtained axial to the discharge.

Figures 1(a), (b), and (c) show the oscilloscope presentation of detected radiation from the last portion of the pulsed dc discharge in helium at 10.2 mm Hg. Time is read left to right at 40 microseconds per major division. Figure 1(d) shows the crystal-detected 40-microsecond pulse of microwave energy at 9375 Mc/sec and approximately 0.5 watt. Figure 1(a), with the microwave absent, indicates clearly the point of discharge termination with time, there being more momentary emission from the afterglow than from the main discharge. Figure 1(b), with the microwave present, shows the effect of quenching at a point on the anode side of the most intense negative glow, while in the wake of the microwave a greater emission is noted ("saving-up" effect[2]). Figure 1(c) shows the effect of enhanced emission in the presence of the microwave, observed at a point on the cathode edge of the negative glow.

A broad flat minimum in the magnitude of the quenched radiation with increase of microwave energy incident presumably indicates an almost complete halting of observable recombination before further excitation by the microwave is appreciable. Thus the residual light is probably due to a normal discharge excitation process, perhaps a result of the "intermediate" electron group. The light that can be quenched and attributed to recombination is experimentally found, with increasing incident microwave energy, to approach the $-\frac{3}{2}$ power law[4] intrinsic in the recombination coefficient. Temperature of the "ultimate" group of electrons in this discharge type has been found by independent Langmuir probe measurements to be approximately 1000°K, which is conducive to strong recombination. A measurement based on the saving-up effect and a knowledge of absolute electron density allows calculation of the recombination coefficient, α—preliminarily $\sim 10^{-8}$ cm^3/ion sec. These indications of recombination in the helium negative glow are consistent with the hypothesis of dissociative recombination[4] and give support to the early measurements of Dewey.[5]

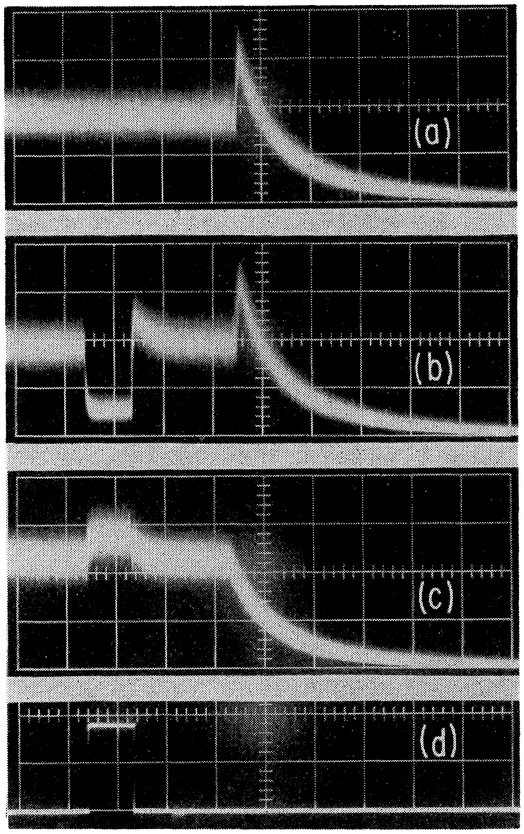

FIG. 1. Quenching and enhanced light emission by a microwave pulse from the negative glow of a cold-cathode dc discharge in helium. (See text for details.)

Similar discharges in neon, argon, and xenon in the pressure range 1–10 mm Hg gave no quenching effect with application of the microwave field, only enhanced emission. Neon with small admixtures of argon gave a small magnitude of quenching at a point close to the anode side of the most intense negative glow, but at no other point in the negative glow or Faraday dark space. Preliminary spectral separation in helium by filters showed the microwave-induced quenching to be an equal percentage of the total quenchable light throughout the visible, but the light attributed to discharge or microwave excitation to be predominantly from the red portion of spectrum.[6]

The afterglows, upon interruption of all the above indicated discharges, gave an almost complete quenching effect, but the maximum incident microwave energy gave enhanced emission (less quench), as for the case of the continuous discharge.

I am indebted to Dr. John A. Bradshaw for many helpful discussions.

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High-Temperature Molecular Beam Microwave Spectrometer*

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MOLECULAR beam spectrometers have the advantage that both Doppler and pressure broadening can be largely avoided. They are especially attractive for high-temperature measurements where these broadening factors become very significant and where the difficulties of heating an entire microwave absorption cell with its sealed windows become increasingly difficult. The sensitive and intricate molecular-beam electric resonance method[1] cannot generally be applied in the upper frequency microwave region. Furthermore, the electric resonance method as usually applied gives the product of the dipole moment, μ, and spectral constant, B, although in some instances[2] (for

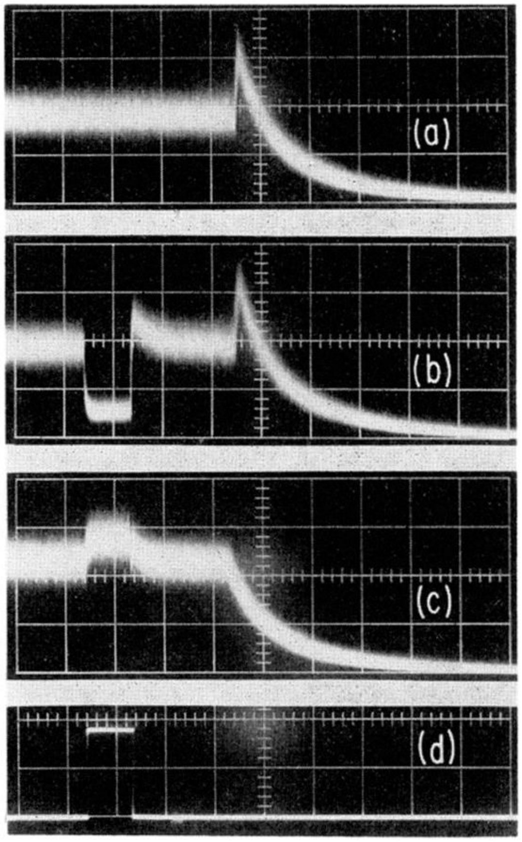

FIG. 1. Quenching and enhanced light emission by a microwave pulse from the negative glow of a cold-cathode dc discharge in helium. (See text for details.)