Letters to the Editor

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Overhauser Effect in a Free Radical

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On theoretical grounds Overhauser[1] has predicted an interaction between paramagnetic and nuclear resonance. If the former is saturated, one of the processes trying to restore thermodynamic equilibrium is such that the change of angular momentum in an electron spin flip is compensated by a change in direction of a nuclear spin. Thus the ground state population of the nuclear spin system is increased. This increase can be detected by an enhanced nuclear resonance. According to Overhauser's first paper this effect would be confined to metals. It has been found in Li by Carver and Slichter.[2] Bloch[3] has pointed out that the effect might expected in nonmetals too. In this letter we give a brief description of a preliminary experiment in which the Overhauser effect was found in the free radical diphenylpicrylhydrazyl (DPPH).

The sample was placed in a glass tube inside a coil, that was inserted in a 3-cm resonant cavity, with the axis perpendicular to the magnetostatic field. The coil consisted of two groups of 20 windings each, separated by a gap of 2 mm in order to increase the penetration of the microwave field into the coil. The cavity, made of rectangular wave guide, was fed by a 70-watt klystron. The incident power could be measured by means of a calibrated attenuator in front of a monitor. Nuclear resonance in the coil was observed by a Thomas oscillator.[4] In DPPH a weak proton resonance was found, the peak height in 10 mm^3 being of the same order as that in 1 mm^3 H_2O with 2.5×10^{17} Fe^{3+} ions mm^{-3} added. In the field where paramagnetic resonance occurred (3300 oersted), the proton resonance was at about 14 Mc/sec.

At high microwave power levels the electron spin resonance showed saturation. At the same time the proton spin resonance increased by Overhauser effect (Fig. 1). During the experiment the sample was kept at room temperature by cooling with a jet of cold air, as it was found that towards higher temperatures the proton peak height increased as a result of decreasing line width. When the peak height was increased by Overhauser effect, no change in line width was observed. The temperature of the sample was checked by a thermocouple. The incident power was limited to 8 w by the cooling capacity of the air jet.

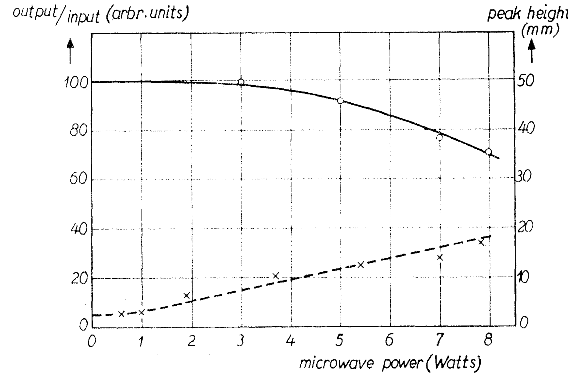

Fig. 1. Solid curve: output/input for electron spin resonance. Dotted curve: peak height of proton resonance on oscilloscope screen. Both are plotted against incident microwave power.

From paramagnetic resonance experiments it is well known that in DPPH there is an appreciable interaction between the electron hole and the nitrogen nuclear spin.[5] Therefore it would be interesting to see if the nitrogen nuclear resonance shows Overhauser effect. Unfortunately the nitrogen resonance will be extremely weak and cannot be detected by a simple oscillator.

We are indebted to Professor Casimir for suggesting the experiment, to Mr. van Iperen for providing the klystron, and to Dr. Klaassens for preparing the free radical sample.

[1] A. W. Overhauser, Phys. Rev. **92**, 411 (1953).
[2] T. R. Carver and C. P. Slichter, Phys. Rev. **92**, 212 (1953).
[3] F. Bloch, Phys. Rev. **93**, 944 (1954). See also J. Korringa, Phys. Rev. **94**, 1388 (1954).
[4] H. A. Thomas, Electronics **25**, 114 (1952).
[5] Hutchison, Pastor, and Kowalsky, J. Chem. Phys. **20**, 534 (1952).

Anomalous Optical Behavior of InSb and InAs

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Burstein[1] has recently proposed an explanation of the anomalous optical behavior of InSb observed by Tanenbaum and Briggs.[2] This explanation is based on the small effective electron mass m_n and the resultant low density of states in the conduction band. In degenerate n-type InSb, the lowest unfilled level in the conduction band rises above the bottom of the band as the electron concentration, n, increases. E_0, the optical energy gap, is determined by the energy separation between the lowest unoccupied level in the conduction band and the corresponding level in the valence band.