

VII. MAGNET LABORATORY RESEARCH

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A. NUCLEAR MAGNETIC RESONANCES

1. Nuclear Resonances in Gases

The high-pressure gas-sample container has been used successfully to obtain a nuclear magnetic resonance in boron 11 in boron trifluoride gas at room temperature and 1150 psi. The signal-to-noise ratio was about the same as that obtainable in liquids containing boron. The linewidth under the stated conditions was small (perhaps a tenth of a gauss). A precise measurement was not made, due to instability in the field. The field stabilizer has a tendency to oscillate at approximately one cycle when stabilizing on a narrow resonance line. Work is in progress on more satisfactory samples for controlling, as well as varying, the phase- and gain-vs-frequency characteristics of the feedback loop by means of a filter. Measurements on the magnet itself show that it alone has much more phase shift (and, at first, less drop in gauss per volt) than a "pure inductance." Various filters and samples have been tried with differing but, thus far, not very satisfactory results.

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2. The Deuteron-Proton Magnetic Moment Ratio

Proton resonances have been observed at 1000 gauss in hydrogen gas at 35 to 150 atmospheres. The relaxation time was found to increase with pressure in agreement with theory (see N. Bloembergen, E. M. Purcell, R. V. Pound: Phys. Rev. 73, 708, 1948) but its magnitude is much smaller than predicted, that is, approximately 0.02 seconds at 100 atmospheres. Deuteron gas resonances have not yet been observed at 1000 gauss because of the low signal-to-noise ratio obtainable as a consequence of low nucleon density combined with low nuclear g-factor. Work has been done in comparing different resonance detection systems with regard to noise level and with particular emphasis on "flicker" noise.

Work at 1000 gauss has been temporarily halted, and time has been spent on improving the automatic field regulator in the barrel-type magnet to be used in this experiment at 15,000 gauss.

Chemical apparatus is being assembled for the preparation of hydrogen deuteride (HD) gas which will be used in this experiment because it provides very nearly the same internal field at the proton and deuteron.

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B. DOUBLE RESONANCE EXPERIMENTS

1. Hyperfine Structure of the $P_{3/2}$ State of Sodium

The $P_{3/2}$, first excited state of sodium has a hyperfine structure consisting of four levels with $F = 3, 2, 1, 0$. The theoretical $\Delta\nu$ is 57.6 Mc/sec. It was originally hoped to measure this by running curves of the deflection produced by turning off the rf power vs the steady magnetic field at a fixed radio frequency. By measuring the position of the maximum and extrapolating to zero field, the field-free separation could, in principle, be measured. Because of the broad lines and because of the fact that the 2-1 and the 1-0 separations become nonlinear at very low fields, this procedure turned out to be impractical. A successful attempt was then made to get a curve of rf deflection vs frequency in zero field. This requires retuning the transmitter and line for every measurement and slows down the data taking considerably. However, a good run was made with vertically polarized light. A resonance type of curve was obtained with a half-width of approximately 18 Mc/sec, which agrees well with the known value of the lifetime of the state. The position of the maximum was 60 ± 4 Mc/sec. (This number is strictly preliminary.) The accuracy is limited at present by noise, not linewidth.

From the empirical curve of quadrupole moments vs atomic number (W. Gordy: Phys. Rev. 76, 139L, 1949), the Na moment is estimated to be $Q = +0.04 \times 10^{-24} \text{ cm}^2$, approximately. The theoretical shift in the 3-2 separation is $\pm 55Q$ Mc/sec or approximately 2 Mc/sec. It is seen, therefore, that for the data to be really interesting from the nuclear physics point of view the probable error should be reduced by at least a factor of two. (Actually two separations are needed; the quadrupole moment is computed from the deviation from the interval rule.)

The position of the maximum of the curve and the half-width make the interpretation very plausible. To confirm this, an attempt will be made to measure the 2-1 separation and to work up a theory of the measurements. Work is also being done toward improving the signal-to-noise ratio.

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