comparison of the amplitudes of the resonance lines of Mo^{95} and Mo^{97} with the ones expected, taking into account the sensitivity of the measuring apparatus, shows that, at least for Mo^{97}, the weakening of the line is caused to a considerable extent by second-order quadrupole effects. At the same time, both resonances in the annealed molybdenum are symmetrical and, in spite of a noticeably different influence of the quadrupole interaction, they have approximately the same width. This brings us to the conclusion that the observed part of the resonances corresponds to nuclei weakly exposed to the influence of quadrupole effects. Because of the sharp dependence of second-order quadrupole effects on the distance, the resonance caused by other nuclei closer to points of structural disturbances becomes so blurred as to be unobservable.[5] The effect of quadrupole interaction on the shift in molybdenum can thus be neglected.

The Knight shift was measured relative to the resonances of Mo^{95} and Mo^{97} in an aqueous solution of K_2MoO_4, i.e., with an accuracy up to the value of the chemical shift in this compound. From a series of successive measurements with metallic and nonmetallic samples in a field of 12600 gausses, we obtained the following values of the shift

$$\frac{\Delta H}{H}(Mo^{95}) = (0.582 \pm 0.005)\%,$$

$$\frac{\Delta H}{H}(Mo^{97}) = (0.586 \pm 0.005)\%.$$

Analogous results were obtained in a field of 8300 gausses.

The fact that the same shift was obtained for both isotopes at two values of the field also proves the assumption that the influence of the quadrupole interaction upon the shift can be neglected.

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STIMULATED R.F. AMPLIFIER WORKING ON HYPERFINE LEVELS OF PARAMAGNETIC ATOMS

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Submitted to JETP editor April 15, 1958

J. Exptl. Theoret. Phys. (U.S.S.R.) **35**, 302-303 (July, 1958)

THE idea of using a paramagnetic crystal as an active element (substance) in stimulated microwave amplifiers was expressed by Bloembergen.[1] Such an amplifier was realized with crystals of salts containing Gd^{3+} ions, by using the dipole transitions between the energy levels of the electron spins of paramagnetic Gd^{3+} ions.[2] In the work of Itoh[3] it was shown that diamagnetic crystals, containing atoms with substantial quadrupole splitting of nuclear spin levels, can be employed in amplifiers at low frequencies (10^6 cps). Abragam and others[4] have pointed out the possibility of the appearance of a stimulated radiation in transitions between the energy levels of proton spins in liquid solutions of paramagnetic ions. We would like to call attention to the possibility of obtaining amplification of signals in the frequency range of 10^8 to 10^9 cps by employing transitions between hyperfine levels of paramagnetic ions.

As an example let us consider crystals of salts containing bivalent ions of the Cu^{64} isotope (ground state $^2D, S = 1/2, I = 1$) (obviously, the conclusions reached here are applicable to other paramagnetic atoms). The scheme of the spin levels of Cu^{++} ions in a strong magnetic field is shown in the figure. The relaxation transition probabilities, the ratio of which determines the possibility of creating negative differences of populations between adjacent hyperfine levels at temperatures of liquid helium and fields of about 5000 oe, have the following values: $W_{a'a} = 10^3$ to 10^4 sec^{-1} (for electron transitions) and $W_{a'b'} = 0.1$ to 1 sec^{-1} (for nuclear transitions). The stationary populations of hyperfine levels that appear upon saturation of the electron transitions, were calculated in our work[5] devoted to the polarization of Cu^{64} nuclei.

Thus, upon saturation of the electron transition $a \rightarrow a'$, the populations of the hyperfine levels are characterized by the following relations:[5]

$$a'/b' = 1 + 3\Delta/2, \quad b'/c' = 1, \quad c/b = 1,$$

$$b/a = 1 + \Delta/2, \quad \Delta = g_e\beta H_0/2kT.$$

We see that the upper of the two adjacent levels a′b′ (or a, b) is much more populated than the

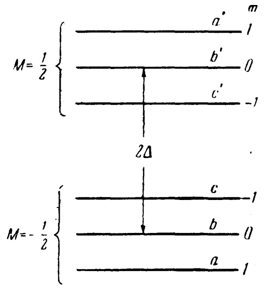

FIG. 1

lower one. Because of that, a signal of frequency $\nu_{a'b'}$ (or ν_{ab}) acting on the crystal should bring about stimulated atomic radiation (emission) at the same frequency. The above-mentioned frequencies will be of the order of 10^8 cps for ions of the iron group and approximately 10^9 cps for rare-earth ions. At $H_0 = 5000$ oe, T = 2 to 4°K, and $N = 10^{19}$ (number of paramagnetic ions), the stored energy for one pair of hyperfine levels (e.g., a′, b′) will be on the order of 1 to 2 ergs. When pulsing with pulse durations of 10^{-4} sec, the output power may reach 10^{-3} w.

Negative differences between the populations of lower and higher adjacent hyperfine levels appear also upon saturation of "forbidden" electron transitions $(M, m) \rightarrow (M+1, m-1)$ (cf. references 5 and 6).

In conclusion, the authors would like to thank A. S. Altschuler for helpful discussions of the results.

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A STUDY OF FAST DEUTERONS AT 3200 m ABOVE SEA LEVEL

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Submitted to JETP editor April 15, 1958

J. Exptl. Theoret. Phys. (U.S.S.R.) **35**, 303-305 (July, 1958)

A study of cosmic ray deuterons was carried out at 3200 m above sea level (Mt. Aragats) using new and improved apparatus — a magnetic spectrometer used in conjunction with two multiplate cloud chambers.[1]

The deuterons were identified by their momentum as measured in the magnetic spectrometer, and by their ionization range in the lower cloud chamber. The new apparatus was different from all previous magnetic mass spectrometers in that it permitted, first, to distinguish properly between particles stopped ionization losses and those stopped by nuclear collisions and, second, to follow the paths of the particles in the upper chamber and to observe the events of local particle production in the matter of the chamber. The total equivalent of the chamber, including the top and the bottom, amounted to ~ 87.5 g/cm² Pb.

In all, ~ 242 deuterons with range in the lower chamber between 1.2 and 5.4 cm Pb were registered. Of these, 81 entered the chamber from the air, 104 were produced in nuclear processes in the matter of the top chamber, and the remaining 57 deuterons could not be traced in the upper chamber for various reasons (the tracks were invisible due to incidence upon non-illuminated region of the chamber, etc.). Simultaneously with these deuterons, ~ 3200 protons were detected.

The fraction of deuterons which came from the air, traversed the top chamber, and were stopped in the lower chamber within the stated range interval, amounts to 0.063 ± 0.0072 of the analogous number of protons, in agreement with references 2 and 3 (taking into account corrections for the optical aperture and nuclear absorption). If one considers the fraction of air deuterons compared with the number of protons of the same momentum range (1.2 to 1.39 Bev/c), the result, 0.086 ± 0.010, coincides with the data of Aivazian.[4]

An analysis fo the produced particles revealed that the number of deuterons produced by primary neutrons is (2.64 ± 0.62) times the number of