x radiation, the quantum energy of which was estimated in special experiments with thick aluminum (1.5 cm) and copper (0.5 cm) filters. These measurements, carried out at a lower laser power, have demonstrated the presence of quanta with energy 100 keV and above. In all probability these γ quanta are knocked out from the walls of the chamber by the fast electrons, since covering the region where the detector is directly visible from the focal point with a thick lead filter (which certainly did not pass the γ quanta) did not lead to a noticeable decrease of the flux. The mechanism of formation of the fast electrons in the laser plasma is not clear.

The minimum number of neutrons can be easily estimated from the fact that at a distance of 60 cm the photomultiplier registered not less than one neutron. This gives for the total number of neutrons not less than 10^3. The neutrons were registered with the energy decreased to 14 J.

In conclusion, we note that the use of heavy targets in the non-equilibrium heating regime, as noted in [5], may turn out to be promising for obtaining powerful deuteron sources.

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POPULATION INVERSION OF THE LEVELS OF THE NUCLEAR MAGNETIC SYSTEM OF THIN-FILM Co^{59} FOLLOWING PULSED MAGNETIZATION REVERSAL

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In [1] there was discussed a possibility of obtaining inverted population of the levels of the nuclear magnetic system of a ferromagnet by pulsed reversal of magnetization. The gist of the process occurring in this case is as follows.

In the equilibrium state the vector of nuclear magnetization μ in the ferromagnet is antiparallel to the vector of the electronic magnetization M. If a pulsed magnetic field causes the electronic magnetization to reverse polarity relative to the anisotropy axis during a time much shorter than the half-cycle of NMR, then μ turns out to be parallel to M, and if this non-equilibrium state exists for a sufficiently long time in comparison with the period of the nuclear precession, then at the NMR frequency the nuclear system will have maser properties.

For a fast rotation of M through 180°, the nuclear-magnetization component μ_z is given according to [1] by

$$\mu_z = \frac{\mu}{1+\sigma^2}\left[1 + \sigma^2 \cos \pi \sqrt{1 + \frac{1}{\sigma^2}}\right], \quad (1)$$

where $\sigma = \omega/\omega_p$; ω is the angular velocity of rotation of M, and ω_p is the angular velocity of the nuclear precession.

The relative inversion is

$$\rho = \frac{1}{2}\left(1 - \frac{\mu_z}{\mu}\right)100\% . \qquad (2)$$

We see that $\rho = 0$ at $\mu_z = \mu$, when the nuclear magnetic system is in the steady state. The total inversion ($\rho = 100\%$) will occur at $\mu_z = -\mu$ after rotation of M through 180° in an infinitesimally short time. Under real conditions, obviously, to observe the maser properties of a ferromagnet it is necessary to obtain $\rho > 50\%$ ($\mu_z < 0$), when the state with inverted levels predominates in the magnetic nuclear system. A convenient object for an investigation of this effect are thin magnetic films, whose magnetization can be reversed within a time $\sim 10^{-9}$ sec [2].

The present paper is devoted to an experimental investigation of the possibility of obtaining the predicted inversion of a nuclear spin system of a film ferromagnet. Polycrystalline Co^{59} films 2000 Å thick, obtained by vacuum sputtering on glass substrates at 220°C in a magnetic field of 70 Oe, had an induced uniaxial anisotropy in the plane (field $H_c \approx 30$ Oe).

The experiment was performed in accordance with a procedure developed by us using a pulsed NMR spectrometer with additional elements for pulsed remagnetization of the investigated films. We simultaneously remagnetized the film and registered the ensuing changes in the amplitude A_e of the spin-echo signal, characterizing the degree of the interaction of the high-frequency field with the component μ_z.

In the case of a pulsed nanosecond reversal of the magnetization of a magnetic film, directly prior to the usual program consisting of two pulses and the echo signal, used to observe the NMR by the Hahn spin-echo method [3], μ_z will vary in accordance with (1) depending on the rate of rotation of M. Accordingly, at $\mu_z = \mu$ or $\mu_z = -\mu$, we have $|A_e| = 1$; at $\mu_z = 0$ (for $\rho = 50\%$), we have $A_e = 0$. For the intermediate values $\mu_z \gtrless 0$ we have $0 < |A_e| < 1$.

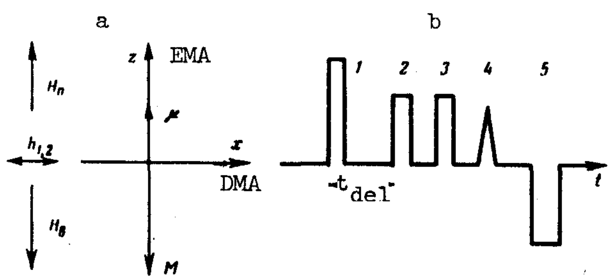

Fig. 1. a - Relative arrangement of the film and of the field acting on it; b - time diagram of sequence of pulses: 1 - H_p; 2, 3 - h_1 and h_2, respectively; 4 - spin-echo signal; 5 - H_r.

Figure 1a shows the relative placement of the axis of the induced anisotropy of the film and the high-frequency ($h_{1,2}$) and pulsed (H_p and H_r) magnetic fields acting in the plane of the film. To the right (Fig. 1b) is shown the time sequence of the aforementioned fields and of the spin-echo signal. Before the two radio pulses at 218 MHz, applied along the difficult magnetization axis (DMA) to obtain the spin-echo signal, the film is remagnetized along the easy magnetization axis (EMA) by a pulsed field H_p with a nanosecond front and an amplitude of several hundred Oe. To return the magnetization to the initial state, a restoring inverse field pulse H_r is applied along the EMA. The repetition frequency of the magnetization-reversal pulses is ~100 Hz, so that at the instant of the next high-speed magnetization reversal the electronic and nuclear spin systems are in the state of equilibrium (for Co^{59} films the time of nuclear longitudinal relaxation is $T_1 \sim (2 - 3) \times 10^{-4}$ sec).

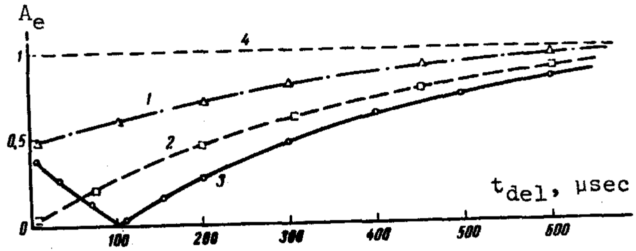

Fig. 2. Plot of $A_e(t_{del})$ at different growth rates of the magnetization-reversing field: 1 - $<0.8 \times 10^{11}$ Oe/sec, 2 - 1.5×10^{11} Oe/sec, 3 - $>3 \times 10^{11}$ Oe/sec, 4 - without remagnetization ($H_p = 0$).

With increasing delay t_{del} between H_p and h_1, as μ_z recovers to μ after perturbation by the remagnetization pulse, there will be observed also a recovery of A_e to $A_e = 1$. The experimental data for different growth times of the pulse field H_p are shown in Fig. 2. For small rates of magnetization reversal, A_e increases from a value $0 < A_e < 1$ to $A_e = 1$ (curve 1 of Fig. 2). At a rate of rotation of M such that $\mu_z = 0$ immediately after the magnetization reversal, the recovery curve $A_e(t_{del})$ emerges from the origin (curve 2). Finally, if $\mu_z < 0$ after the magnetization reversal, then $|A_e| > 0$; with increasing t_{del}, $A_e \to 0$ ($\mu_z(t) = 0$) and then recovers to $A_e = 1$ (curve 3). All three curves are exponentials ($T_{1_p} = 3 \times 10^{-4}$ sec). Curve 3 indicates that an inversion $\rho = 70\%$ was attained after the magnetization reversal, and its value was greater than 50% for about 100 μsec.

Thus, we have demonstrated experimentally the possibility of obtaining inverted population of the levels of a nuclear magnetic system, we obtained a stable NMR signal from a nuclear system inverted by a pulsed magnetic field.

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COMPRESSION OF PLASMA BY A GROWING LONGITUDINAL MAGNETIC FIELD IN THE TOKAMAK

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One of the possible methods of heating a plasma in Tokamak systems is to compress the plasma by increasing the main longitudinal field H. Simple considerations based on ideal magnetohydrodynamics show that the plasma density n(r, t) in the center of the pinch should increase linearly with the field, and