MAGNETIC ACTION OF LIGHT IN THE RECORDING OF AN OPTICAL IMAGE ON A THIN FERROMAGNETIC FILM

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While recording optical images on thin ferromagnetic films by the thermal method [1, 2], we observed that the angle of rotation of the magnetization in the illuminated regions of the film depended on the direction of the light polarization. The maximum rotation angle α was observed in the case when the magnetic vector $\vec{h}$ of the light wave was in the plane of the film perpendicular to the direction of the initial domain orientation, i.e., it coincided with the direction of the rotating field $\vec{H}$ applied to the film during the recording. The difference between $\alpha_{max}(\vec{h} \parallel \vec{H})$ and $\alpha_{min}(\vec{h} \perp \vec{H})$ was 5 - 15°.

The experiments were performed with permalloy films (83% Ni, 17% Fe) 6000 Å thick, having a strip domain structure (domain width 0.34 μ). The film was magnetized beforehand with a strong orienting field aligning the domains in a definite direction. This field was then removed and replaced, at an angle of 90° (Fig. 1), by the recording field $\vec{H}$, which tended to overcome the rotation coercive force and to turn the domain magnetization to its own direction. The film prepared for image recording in this manner was then illuminated through masks of various shapes with pulses of high-power polarized radiation (P = 2 - 6 kW) from a few-mode free-running neodymium laser (λ = 1.06 μ). To obtain emission with a small number of modes, an amplifier system was used, comprising a master generator and an amplifier with active element dimensions 10 x 130 mm. The light was polarized with a trihedral prism to which the laser radiation was applied at the Brewster angle.

The dependence of the angle of domain rotation α on the direction of polarization of the incident light, observed in these experiments, can be attributed to the magnetic action of the light wave on the quasi-equilibrium system of magnetic moments existing in films of this type. The energetically most favored state of a film placed in a magnetic field is

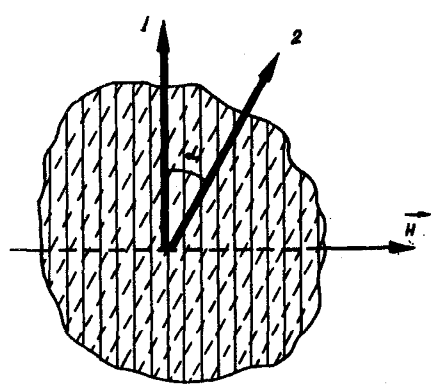

Fig. 1. Arrangement of domains and of recording field in the plane of the film: 1 - direction of initial domain orientation, 2 - direction of domains after rotation under the influence of the field H (in the exposed sections of the film).

obviously one in which the projection of the magnetization vector on the plane of the film in each domain is parallel to this field, i.e., when $\alpha = 90^\circ$. In films with strip domains, however, there exists a strong magnetic "friction," connected with the energy lost in the realignment of the domain boundaries. This "friction" prevents the system from going over into the state with minimum energy and retains the system (if the field H is not too strong) in a certain intermediate state with $\alpha \neq 90^\circ$. This relation is subject to hysteresis. This means that after turning through a certain angle $\alpha(H)$ under the influence of the field H, the system of strip domains does not return to the initial state after the removal of the field, but remains turned through the same angle $\alpha(H)$. This feature of films of this type cause the appearance of their detecting ability relative to an alternating field, whereby the domains rotate, under the influence of a pulsating field $H_1 + H_0 \sin\omega t$ $(h_0 < H_1)$ through an angle α_2 corresponding on the $\alpha(H)$ curve to a value $H_2 = H_1 + h_0$ (Fig. 2). In the case when $\vec{h} \perp \vec{H}$, the influence of the alternating field hardly comes into play (if $h \ll H = H_1$) and $\alpha = \alpha_1$, i.e., the rotation angle corresponds to the value of H_1 on the $\alpha(H)$ curve. At low frequencies, the effect of detecting an alternating magnetic field by films with strip

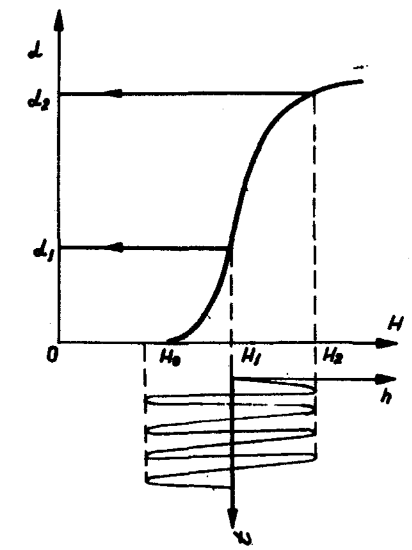

Fig. 2. Magnetization curve of film in a rotating film. H_0 - threshold value of recording field, determined by the coercive force of the film relative to the domain rotation.

domains was observed by us earlier many times. It was unclear, however, whether the effect still holds for frequencies corresponding to the optical band of the electromagnetic spectrum.

Our results apparently confirm this possibility. In the described experiments, the value of h_0 (the amplitude of the magnetic vector of the light wave on the surface of the magnetic film) was determined by calculation from the measured value of the radiation power P, and ranged from 4 to 8 Oe. The difference between the fields H_2 and H_1, corresponding on the $\alpha(H)$ to the experimentally observed maximal $(\vec{h} \parallel \vec{H})$ and minimal $(h \perp H)$ angles of domain rotation, coincided with the value of h_0 within the limits of the measurement error, ± 30% (the power was measured calorimetrically). Such a good agreement[1)] between $H_2 - H_1$

[1)] Agreement was expected only in order of magnitude, since no account was taken of effects connected with the small depth of penetration of the light in the film, and with the spiked character of the laser operation.

and h_0 agrees with the assumption that the experimentally observed dependence of α on the direction of the light polarization is due to the magnetic action of the light wave on the quasiequilibrium system of magnetic moments of the film, which retains its detecting properties also in the optical band. It is possible that these properties are retained also at higher frequencies.

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[2] L. M. Klyukin, V. A. Fabrikov, and A. V. Khromov, Fiz. Met. Metallov. 27, 615 (1969).

OBSERVATION OF ULTRASHORT RADIATION PULSES IN STIMULATED SCATTERING OF LIGHT IN THE RAYLEIGH LINE WING

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We report in this paper the first experimental observation of ultrashort or picosecond radiation pulses (PP) produced by stimulated scattering of light in the Raleigh-line wing (SRW).

The possible occurrence of PP in the SRW process, with a duration on the order of the anisotropy relaxation time τ, was pointed out earlier [2] by Fabelinskii and the present authors. This possibility has now been experimentally confirmed.

The SRW was excited by a giant pulse from a ruby laser [1] of power $\sim$ 150 - 200 MW, duration 10 - 15 nsec, and spectral width $\sim 2 \times 10^{-2}$ cm^{-1}. The exciting light was focused into a vessel with nitrobenzene 10 cm long, with focal distances f = 3 and 1.5 cm.

Feedback was produced between the laser and the scattering medium. The scattered light was observed in the forward and backward directions.

The method of two-photon luminescence was used to observe the PP in the SRW [3]. A narrow beam of the scattered light passed through a vessel containing a solution of rhodamine-6G in ethyl alcohol and was reflected backwards from the mirror M (Fig. 1). Maxima of the two-photon luminescence should occur at the points of encounter of the forward PP and those reflected from the mirror. If there is only one such pulse, then the maximum luminescence should be observed at the mirror; if there are several, then a corresponding number of maxima are observable also at a definite distance from the mirror. The $T = 2\ell/c$ between two PP can be determined from the distance ℓ between the mirror and the first luminescence maximum, and the width $\Delta\ell$ of this luminescence maximum yields the PP duration $t_s = \Delta\ell/c$, where c is the velocity of the light in the medium.

Ultrashort pulses in SRW were observed both in the direction of propagation of the exciting radiation, and in the opposite directions. Such pulses could be registered only