amplitude with increasing distance from the resonance causes the period of the oscillations to increase. The observed effect is a nuclear analog of the "Pendellosung" effect known in x-ray optics [5], but there the oscillations of the intensity are connected only with the change of the thickness. It is important to emphasize that the very presence of these oscillations in our spectrum, as well as the effect of suppression of the nuclear absorption of the γ rays, serves as proof of the collective character of the interaction of the γ rays with the crystal.

The authors are deeply grateful to Yu. Kagan and A.M. Afanas'ev for a discussion of the results, to V. Kon for help with the calculations, and to M.A. Volkov and I.B. Filippov for taking part in the experiment. The material enriched with Fe^{57} was obtained from the USSR State Fund of Stable Isotopes.

[1] A.M. Afanas'ev and Yu. Kagan, Zh. Eksp. Teor. Fiz. 48, 327 (1965) [Sov. Phys.-JETP 21, 215 (1965)].
[2] V.V. Sklyarevskii, G.V. Smirnov, A.N. Aftem'ev, B. Sestak, and S. Kadeckova, ZhETF Pis. Red. 8, 295 (1968) [JETP Lett. 8, 181 (1968)].
[3] V.V. Sklyarevskii, G.V. Smirnov, A.N. Artem'ev, R.M. Mirzababaev, B. Sestak, and S. Kadechkova, ibid. 11, 531 (1970) [11, 363 (1970)].
[4] V.K. Voitovetskii, I.L. Korsunskii, A.I. Novikov, and Yu.F. Pazhin, ibid. 11, 149 (1970) [11, 91 (1970)].
[5] B.W. Batterman and H. Cole. Rev. Mod. Phys. 36, 681 (1964).

PRODUCTION OF 3-MOe PULSED MAGNETIC FIELDS BY DISCHARGING A CAPACITOR BANK

A.M. Andrianov, V.F. Demichev, G.A. Eliseev, and P.A. Levit
Submitted 14 May 1970
ZhETF Pis. Red. 11, No. 12, 582 - 585 (20 June 1970)

The production of magnetic fields of intensity exceeding a million Oersteds, even for a very short time, entails considerable experimental difficulties. The largest magnetic field intensity was registered in magnetic-cumulation experiments [1, 2]. Discharge of a capacitor bank through a solenoid yielded a field of intensity up to 2.5 MOe [3, 4]. The maximum value of the field in the solenoid depends on the rate of growth of the current and on the shape and properties of the solenoid material.

The purpose of the experiments reported here was to choose a solenoid material capable of withstanding pulsed loads in the best fashion and of ensuring maximum field intensity.

The current source in our experiments was a bank of pulsed capacitors with stored energy 25 kJ. The discharge current was in the form of a damped sinusoid with decrement 1×10^5 sec^{-1}. The time of the first current half-cycle was 5.7 μsec, and the maximum amplitude was 1.5 MA.

The experiments were performed with single-turn solenoids made of different materials. The inside diameter of the solenoid was 2.1 mm and its length 2.5 mm. The solenoids were secured in a massive steel frame, which was connected with the current busses of the capacitor bank.

The field intensity was measured with a magnetic probe constituting a four-turn coil 1.1 mm in diameter. The probe was placed in a teflon sleeve and was impregnated with castor oil. The probe was calibrated in a homogeneous field of known intensity. The probes were not damaged and could be used repeatedly even in fields of 2 - 3 MOe.

In each experiment we registered simultaneously oscillograms of the current through the solenoid, of the magnetic field intensity, and of its derivative. In the reduction of the oscillograms we also carried out graphic integration of the field-derivative signal.

The measured field intensities of the solenoids made of some of the tested materials are shown in Fig. 1. The lag of the growth of the field intensity relative to the growth of the current is due to the increase of the effective dimensions of the current layer. The rate of change of the dimensions of the current layer depends on the physical and mechanical properties of the solenoid material. In particular, the denser the solenoid material, the larger the limiting field amplitude. This favors the conclusion that the inertial endurance of the material has a strong influence on the maximum magnetic field. The mechanical strength of the material in fields 2 - 3 MOe, when the pressure of the magnetic field reaches 160 - 360 thousand atmospheres, has no strong effect on the rate of expansion of the internal cavity of the solenoid, and consequently on the maximum field. The mechanical strength influences in such fields only the final dimension of the internal aperture in the solenoid. The character of the damage indicates intense plastic flow of the material of the solenoids (Fig. 2). Some of the materials (e.g., molybdenum) were in addition subject to brittle failure.

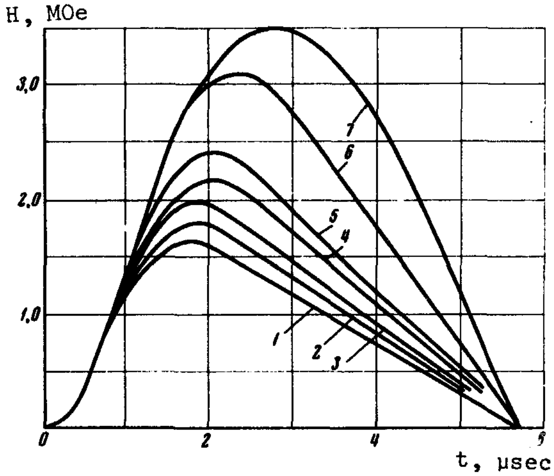

Fig. 1. Time dependence of the magnetic field intensity in solenoids made of different materials: 1 - aluminum and duraluminum, 2 - titanium, 3 - copper and steel, 3, 4 - molybdenum, 5 - copper-tungsten composition AVM, 6 - tantalum, 7 - calculated curve for an idealized nondestructive solenoid.

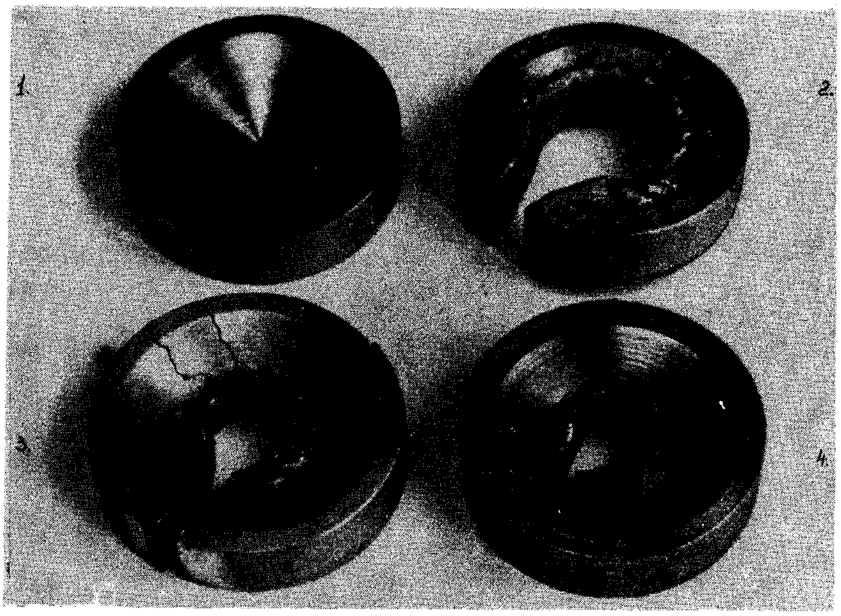

Fig. 2. Photographs of solenoids: 1 - initial; 2 - copper, after producing a field of 2.0 MOe, 3 - molybdenum, after producing a field of 2.2 MOe, 4 - tantalum, after producing a field of 3.1 MOe.

The absolute values of the magnetic field intensity obtained in our experiments are not the limiting ones for the tested materials. The registered values of the magnetic fields (from 1.6 MOe for aluminum to 3.1 MOe for tantalum) can be increased not only by further increasing the current growth rate, but also by changing the shape and the dimensions of the solenoid. In particular, the limiting field in a solenoid of any shape can be increased by increasing its dimensions while maintaining constant the ratio of the length to the diameter. An increase of the volume of the field requires, naturally, a larger energy source.

An analysis of the results shows that the material most promising for the production of superstrong fields is tantalum. It has the optimal combination of properties: high melting temperature, high density, and good strength characteristics. Under the conditions of our experiments, the amplitude of the magnetic field in a tantalum solenoid was 1.5 times larger than in the analogous copper solenoid.

The high endurance of tantalum and its advantages over other tested materials were confirmed also in experiments in which strong pulsed fields were obtained in solenoids designed for repeated action. A field of 1.0 MOe in a tantalum solenoid with inside diameter 5 mm and length 5 mm could be obtained, in reproducible fashion, several dozen times. A 500 kOe field intensity could be obtained repeatedly in a large-volume solenoid thousands of times.

The use of pulsed solenoids of materials such as tantalum extends the possibility of performing different investigations in fields of the megagauss range without destroying the investigated objects.

[1] A.D. Sakharov et al., Dokl. Akad. Nauk SSSR 165, 65 (1965) [Sov.-Phys.-Dokl. 10, 1045 (1966)].
[2] C.M. Fowler et al., J. Appl. Phys. 31, 588 (1960).
[3] D.W. Forster and J.C. Martin, Actes du colloque international sur Les Champs Magnetiques Intenses, p. 361, 1967, Paris.
[4] J. Shearer, ibid. p. 355.

RUBY LASER WITH OPTICAL DELAY LINE INSIDE THE RESONATOR

L.S. Kornienko, N.V. Kravtsov, E.G. Lariontsev, and N.I. Naumkin
Nuclear Physics Research Institute of the Moscow State University
Submitted 18 May 1970
ZhETF Pis. Red. 11, No. 12, 585 - 588 (20 June 1970)

1. The characteristics of solid-state lasers were investigated until now at resonator lengths on the order of several meters. The use of optical delay lines (ODL) makes it possible to produce lasers with effective resonator lengths of several hundred meters. The characteristics of such a laser have many distinguishing features compared with the ordinary laser [1]. We present below some results of an experimental investigation of a ruby laser at a resonator length L up to 400 m.

The laser investigated by us consisted of an optical resonator made up of two flat mirrors with reflection coefficients 99.6 and 75%. A ruby crystal, excited by two flash lamps, and the ODL were placed inside the resonator.

The ODL was made up of two spherical mirrors with radius of curvature 5000 mm, diameter 120 mm, and reflection coefficient 99.6%.

We investigated the dependence of the threshold pump energy W_{thr} on the effective length of the laser.