neodymium ions. Since at $j = 1$ A/cm^2 the rate of pair generation is $g \approx 10^{25}$ pairs/cm^{3}sec, it follows that the number of excited neodymium ions in this case is $\Delta N = g\tau_S \approx 3 \times 10^{19}$ cm^{-3}, which is close to the Nd^{3+} concentration in the crystal. An investigation of the emission from resonators 2 mm long at 293°K has shown that if silver coatings with reflectivity 97% are deposited on their end faces, the directivity pattern of the radiation from the resonator end narrows down from 30° to 10° for radiation with $\lambda_M = 10637$ Å, corresponding to the transition $^4F_{3/2} \rightarrow {}^4I_{11/2}$, and to 15° for the emission $\lambda_M = 4007$ Å, which corresponds to the transition $S \rightarrow {}^4F_{7/2}$ (Fig. 2). The emission line of the $^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition was narrowed down from 20 to 7 Å (Fig. 3). The fact that the directivity patterns and the emission lines become narrower when the surfaces of the resonators are silvered indicates stimulated emission. The stimulated character of the radiative transitions is confirmed also by the fact that the intensity of the radiation in a direction close to normal to the plane of the silvered ends of a resonator with R = 97% decreases only to one-half of the intensity of the radiation from the front unsilvered face of the resonator, whereas in the absence of stimulated emission, the intensity of radiation from the ends should be approximately one-thirtieth the intensity of emission from the front face. When j is decreased from 0.2 to 10^{-2} A/cm^2, the directivity pattern remains unchanged, and the radiation intensity decreases linearly with j, from which it follows that the threshold of the stimulated emission lies at electron-current densities $j < 10^{-2}$ A/cm^2. The results of the investigations have shown that electronic excitation makes it possible apparently to construct a laser based on $Y_3Al_5O_{12}:Nd^{3+}$ not only in the infrared band, but also in the visible region, using transitions from the S level. It is of interest to excite with electron beams garnet crystals activated with other ions, such as gadolinium. This may yield stimulated emission in the ultraviolet region, with an approximate efficiency 20%.

The authors are grateful to A.M. Prokhorov and V.S. Vavilov for continuous interest in the work and for a discussion of the results.

[1] N.G. Basov, O.V. Bogdankevich, and A.G. Devyatkov, Dokl. Akad. Nauk SSSR 155, 783 (1964) [Sov. Phys.-Dokl. 9, 288 (1964)].
[2] E.W. Mutchell and P.D. Townsend, Proc. Phys. Soc. 81, 12 (1963).
[3] Yu.V. Voronov and Yu.P. Timofeev, Zh. Prikl. Spektr. 2, 126 (1965).
[4] V.S. Vavilov, E.L. Nolle, and S.N. Maksimovskii, Fiz. Tverd. Tela 7, 1558 (1965) [Sov. Phys.-Solid State 7, 1253 (1965)].
[5] Yu.K. Voron'ko, B.I. Denker, V.V. Osiko, A.M. Prokhorov, and M.I. Timoshechkin, Dokl. Akad. Nauk SSSR 188, 1258 (1969) [Sov. Phys. Dokl. 14, 998 (1970)].
[6] G.H. Dicke and H.M. Crosswhite, Appl. Optics 2, 675 (1963).

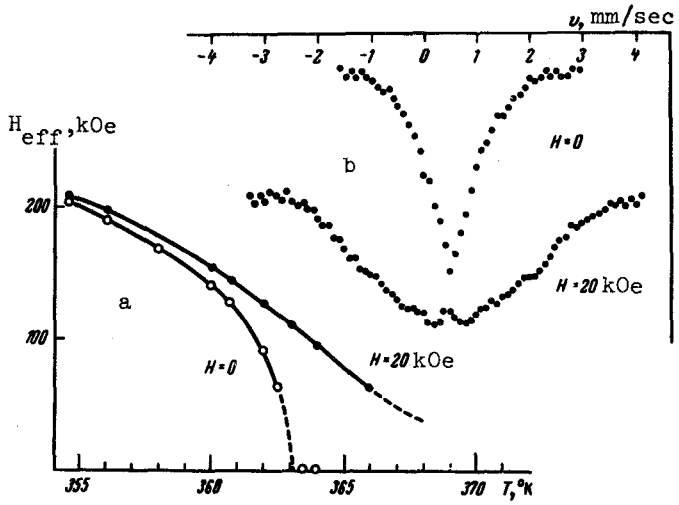
OBSERVATION OF INDUCED ANTIFERROMAGNETISM ABOVE THE NEEL POINT IN FeF_3

V.Ya. Gamlitskii, S.S. Yakimov, V.I. Nikolaev, and N.F. Simonov
Submitted 21 December 1970
ZhETF Pis. Red. 13, No. 3, 129 - 130 (5 February 1971)

In the investigation of the Mossbauer spectrum on Fe^{57} nuclei in the antiferromagnet FeF_3 in an external magnetic field H up to 20 kOe, we have observed induced antiferromagnetic ordering in the temperature region above the magnetic-transformation point (T_N). According to crystallographic [1] and neutron-diffraction [2] data, FeF_3 forms a bimolecular rhombohedral cell and has an antiferromagnetic structure with isotropy of the "easy plane" type. Such structures, in accordance with the Dzyaloshinskii theory [3], admit of the existence of weak ferromagnetism due to the "tilting" of the antiferromagnetic

sublattices. The macroscopic magnetic moment of FeF_3 is 0.44 cgs emu/g at 79°K [4].

On the basis of the thermodynamic theory of [3], Borovik-Romanov and Ozhogin [5] have shown that in antiferromagnets with "tilting" of the sublattices, an external magnetic field can restore the antiferromagnetic order above the Neel point (and can lead to its growth below T_N). This effect was observed by the antiferromagnetic-resonance method in the compound $NiCO_3$ [6].



a - Temperature dependence of H_{eff} at the Fe^{57} nuclei in the antiferromagnet FeF_3 in the region of T_N at H = 0 and H = 20 kOe; b - Mossbauer absorption spectra of γ quanta with energy 14.4 keV of the Fe^{57} nuclei in FeF_3 at 363°K. Source - Co^{57} in stainless steel.

In our investigations we used a polycrystalline FeF_3 sample made of iron 99.95% pure enriched with Fe^{57} (83%). The metallic iron was fluorided with elementary fluorine in nickel apparatus at temperatures 350 - 400°C. The Neel temperature was determined by thermal scanning and was found to be 363.2°K, in agreement with the previously published data [4, 7]. The investigation of the Mossbauer effect was carried out in a temperature range 283 - 400°K. The direction of the magnetic field was perpendicular to the direction of the flux of registered γ quanta.

The Mossbauer spectra were processed with a computer, the intensities, positions, and widths of the individual components being varied independently. The results are shown in the figure (where by way of an example we show also the spectra for one of the temperatures). It is seen that at $T > T_N$ an external magnetic field of 20 kOe induces an effective magnetic field $H_{eff} \approx 100$ kOe at the Fe^{57} nuclei.

A comparison of the intensities of the spectral components at H = 0 and $H \neq 0$ has shown that in a magnetic field the predominant direction of the sublattice moments is perpendicular to H. Consequently the type of antiferromagnetic ordering peculiar to FeF_3 is retained in this case when $T > T_N$. Below T_N, a growth of the antiferromagnetic order is likewise observed in the entire range of the investigated temperatures.

It is important that in similar investigations, carried out by us on the antiferromagnetic compound $FeSn_2$, in which there is no "Dzyaloshinskii interaction," the effect of induction of H_{eff} on the Fe^{57} nuclei was not observed.

We are grateful to I.K. Kikoin for continuous interest in the work, to V.I. Ozhogin for valuable discussions, and to V.I. Bogachev for great help.

[1] M.A. Hepworth, K.H. Jack, R.D. Peacock, and G.J. Westland, Acta Crystallogr. 10, 63 (1957).
[2] E.O. Wollan, H.R. Child, W.C. Koehler, and M.K. Wilkinson, Phys. Rev. 112, 1132 (1958).

[3] I.E. Dzyaloshinskii, Zh. Eksp. Teor. Fiz. 32, 1547 (1967) [Sov. Phys. JETP 5, 1259 (19 7)].
[4] L.M. Levinson, J. Phys. Chem. Solids 29, 1331 (1968).
[5] A.S. Borovik-Romanov and V.I. Ozhogin, Zh. Eksp. Teor. Fiz. 39, 27 (1960) [Sov. Phys. JETP 12, 18 (1961)].
[6] L.A. Prozorova, ibid. 57, 1967 (1969) [30, 1065 (1970)].
[7] G.K. Wertheim, H.J. Guggenheim, and D.N. Buchanan, Solid State Comm. 5. 537 (1967).

TRANSVERSE MODE LOCKING IN AN INJECTION LASER

S.S. Vyshlov, L.P. Ivanov, A.S. Logginov, and K.Ya. Senatorov
Physics Department of the Moscow State University
Submitted 22 December 1970
ZhETF Pis. Red. 13, No. 3, 131 - 133 (5 February 1971)

Mode locking in optical lasers can be the consequence of the nonlinear interaction of the modes in the active volume of the resonator [1]. In the case of longitudinal mode locking the laser emits, as is well known, a periodic sequence of ultrashort light pulses. Axial-mode locking was observed in an injection semiconductor laser with inhomogeneous excitation, operating with an external resonator [2], and in a semiconductor laser with electronic excitation [3].

In the case of transverse mode locking, the generation region should experience a periodic displacement over the resonator mirror, and swinging of the directivity pattern of the radiation should occur. The frequency of such a displacement is equal to the difference between the frequencies of the neighboring transverse modes [4]. Transverse-mode locking was observed in neodymium-glass solid-state lasers [3] and in CO_2 gas lasers [6].

In this paper we present the results of an investigation of the effect of transverse-mode locking in an injection semiconductor laser.

We investigated samples of GaAs laser diodes obtained by the epitaxial and diffusion methods and operating in the pulsed regime at 300°K. The laser-diode resonator length was 300 - 400 μ. The pump pulse duration was adjustable from 30 to 100 nsec. The threshold currents of the investigated samples were usually 20 - 60 A.

The dynamics of the emission of laser diodes in the near and far zones was investigated by the method of electron-optical chronography [7]. The time resolution of the developed apparatus was $\sim 10^{-11}$ sec.

Figure 1a shows a time scan of a glowing laser-diode p-n junction. The excess of the pump current over threshold was 1.5%. It is seen from Fig. 1a that the generation region moves periodically over the resonator mirror along the p-n junction.

Figure 1b is a time scan of the far zone of the laser diode emission. To obtain the photograph in Fig. 1b, a cylindrical lens was placed in front of the photocathode of the electron-optical converter and "compressed" the directivity pattern of the radiation in a plane perpendicular to the plane of the p-n junction.

For the sample investigated, the maximum displacement of the generation region over the resonator mirror was 50 μ, and the length of the generation region along the p-n junction was ∿15 μ. The maximum swing angle of the directivity pattern was ∿5°.