# STUDIES OF PHOTOINDUCED CHANGES IN MODULATED MAGNETIC STRUCTURE PARAMETERS

**Fayziev Shakhobiddin Shavkatovich*; Saidov Kurbon Sayfulloyevich**; Sulaimonov Sherzod Baxshulloevich*****

*Candidate of Science of Physics and Mathematics,
UZBEKISTAN

**Candidate of Science of Physics and Mathematics,
UZBEKISTAN

***Department of Physics Master,
Bukhara State University, Bukhara, UZBEKISTAN
Email id: shakhobiddin_shavkatovich@umail.uz

**DOI: 10.5958/2249-7137.2022.00050.7**

## ABSTRACT

*This article is devoted to the study of the dependence of the magnetically linear birefringence in a FeBO3: Mg crystal on the orientation of the antiferromagnetic moment. The emergence of a magnetically modulated structure (MMS) in a crystal doped with an FeBO3 impurity was studied by the magneto-optical method. The studies were carried out in the temperature range $80 \leq T \leq 290K$ in a magnetic field $H \leq 50$ Oe with the orientation of the vector H parallel to the (111) plane. Illumination with a light flux and visual observations of the domain structure (DS) and measurements of the Faraday effect were carried out.*

**KEYWORDS:** *Domain Structure, Modulated Magnetic Structure, Magnetic Linear Birefringence, Crystal, Domain, Magnetic Moment, Axis Of Magnetization, Illumination, Orientation Of Domains, Anisotropy.*

## INTRODUCTION

In many magnetically ordered crystals, under the action of light, peculiar new magnetic and optical properties appear, which are absent without additional illumination. In a $FeBO_3$ crystal, Ni ions illuminated with unpolarized white light produce uniaxial magnetic anisotropy. This axis does not coincide with the crystallographic anisotropy axes **[1].** In theory, the photoinduced excitation of MMS results from the magnetoacoustic interaction between the complexes formed by the matrix Fe ions and impurity Ni ions, which is insignificant in the absence of illumination, but the moment of exposure of the crystal increases. This, in principle, allows the occurrence of MMS in an $FeBO_3$ crystal with an impurity without additional illumination, thus the light effect should affect the modulation of the magnetic property of the crystal. **[2]** Determining such an effect on the MMS parameters would make it possible to analyze the reasons for the appearance of a stable inhomogeneous magnetic state in this crystal. To reveal the effect of additional illumination on the period and stability of $FeBO_3$:Mg MMS, photomagnetic studies of the crystal were carried out. The studies were carried out by the magneto-optical method in the frequency range of the optical transparency of the crystal (in the wavelength range of 0.5 μm). **[3]** Temperature range 80 ÷ 290 K in a magnetic field $H \leq 50$ Oe with the orientation of the vector H parallel to the (111) plane at small angles of light incidence on the sample plane. The light flux scanning the crystal was passed through a ZS-1 band-pass glass filter and had an intensity of ~ $10^{-5}$ W/sm$^2$. It was found that pre-illumination of the sample (at T = 80 K, H = 0) changed the period and conditions for the existence of MMS, which is realized in the crystal when it is magnetized along difficult axes oriented at an angle of 30° to the Y axis. With this magnetization geometry, a system of bands appears at $H = H_1 \approx 5.5$ Oe. The bands exist in a certain T-dependent interval of the magnetizing field ΔH and disappear when the field reaches the value $H_c \approx 17$ Oe at T = 80 K. up to $H_c \approx 21$ Oe, and its period increased compared to the value of d observed on the "unilluminated" sample, while the jumplike nature of the dependences d(H) and d(T) was retained (Figure. 1, 2). The change in the parameters of the system of bands that arises at H || X, occurred only when a sample pre-magnetized (in a field H = 5 Oe, H || X) to a single-domain state was subjected to long-term exposure: in this case, an increase (by approximately 10%) in the period d and the interval ΔH of fields was also observed the existence of MMS. It turned out that in both cases the exposure. **[4-9]**

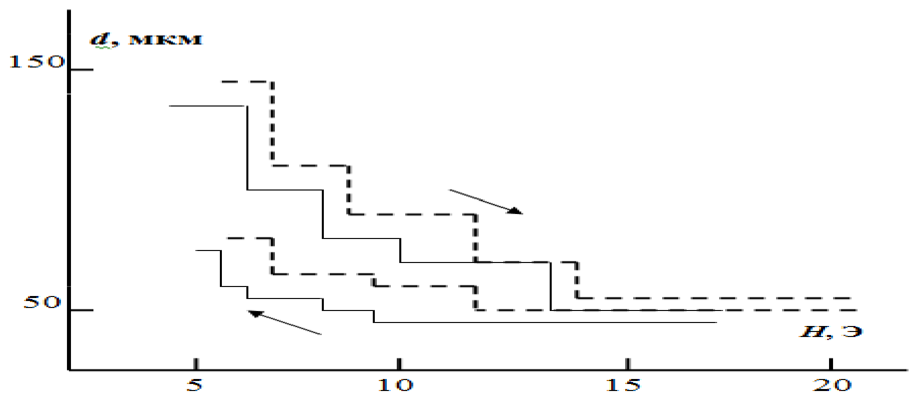


Figure. 1. Field dependence of the spatial period of the modulated $FeBO_3$:Mg magnetic structure obtained at T = 80 K (vector H lies in the (111) plane and is oriented at an angle of 30° to the Y axis). The solid broken line is the "unexposed" sample, the dotted broken line is the sample was preliminarily exposed to unpolarized white light at H = 0 for 10 min. The arrows indicate the direction of the magnetic field sweep **[10-14].**

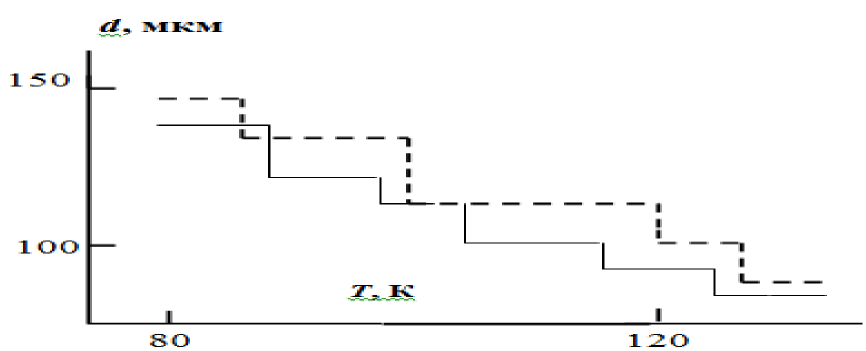


Figure. 2. Temperature dependence of the spatial period of the modulated $FeBO_3$:Mg magnetic structure obtained at H = 6.5 Oe (the H vector lies in the (111) plane and is oriented at an angle of 30° to the Y axis). The designations are the same as in Fig. one.

**Sample under white light did not change (within the experimental error ± 2 K) the band disappearance temperature $T_c$.**

The period of the MMS of the “exposed” (at $\tau$ = 10 min) crystal realized at given H ($H_1 \leq H \leq H_c$) and T ($80 \leq T \leq 130$ K) (as well as the value of $H_c$) did not change further under the action of light. After turning off the additional illumination, the values of d and Hc slowly relaxed (at T = 80K for~60 min) to their values characteristic of an “unilluminated” crystal (relaxation occurs as a result of two or three abrupt changes in the values of d and $H_c$, bringing them closer to to their equilibrium values for the given H and T values). After heating the “illuminated” sample to $T > T_c$ and its subsequent cooling (in the absence of additional illumination) to T = 80 K, the curves d(H, T) and F(H) coincided within the accuracy of the experiment with the corresponding curves obtained after the first sample cooling. $T_o$ establish the spectral region of additional illumination, which most effectively affects the magnetic state of $FeBO_3$:Mg, experiments were carried out in which the spectral composition of the light incident on the sample was varied: by successively introducing filters with a clear transmission boundary into the additional illumination channel, various parts of the white light spectrum were cut off. As a result, it turned out that infrared radiation with $\lambda \sim 0.8 \div 0.9$ μm has the most noticeable effect on the MMS and magnetic hysteresis loops of the studied crystal. As an illustration of this conclusion, the table shows the values of the fields $H_c$ obtained from the dependences F(H) of a sample preliminarily kept at T = 80 K for $\tau$ = 10 min under a light flux with a different spectral composition (each value of Hc was obtained after heating the “exposed » sample up to $T > T_c$ and its subsequent exposure at T = 80 K, H = 0). Whence it can be seen that light with wavelengths $0.8 > \lambda > 0.9$ μm has practically no effect on the value of $H_c$ (for an "unexposed" sample, $H_c$ = 1.61 Oe (see Fig. 1)). **[15-23]** It is significant that $FeBO_3$:Mg illumination at $T > T_c$ did not change the parameters of the MMS; in addition, in all the experiments performed, no dependence of the photoinduced effects on the polarization of the light flux incident on the crystal was found.

**REFERENCES**


1. Fedorov YuM, Leksikov AA, Aksenov AE. Photo-induced optical anisotropy in iron borate. JETF. 1985;89:2099–2112.
2. Fayziev ShSh, Saidov KS, Sulaymonov ShB. Magnetic properties of rare earth garnets. Academy. 2021;4(67):4-7
3. Sharipov MZ, Faiziev ShSh. Nizomov ShK. Features of the magneto-optical properties of a single crystal of iron borate. Science, technology and education. 2021;2-2(77):5-9
4. Bakhtiyorovna YN, Shavkatovich FSh. Modulated magnetic structures and models of their theoretical expression. Academicia: an international multidisciplinary research journal. 2021; 1(11):1172-1175
5. Fayziev ShSh, Saidov KS. Nizomova ShK. Electronic structure of the main multiplet of the dysprosium ion in orthoaluminate. Academy. 2020;11(62):4-6.
6. Fayziev ShSh, Saidov KS, Askarov MA. Dependence of the magnetically modulated structure on the field orientation in the FeBO3:Mg crystal. Bulletin of science and education. 2020;18-2(96):6-9.

**7.** Shavkatovich ShF, Baxtierovna NY. Changes occuring in ferromagnets by adding some mixture. Scientific reports of Bukhara State University. 2020;1(4):8-13.

**8.** Sharipov MZ, Sokolov BYu, Faiziev ShSh, Mirzhonova NN. Effect of rearrangement of the magnetic structure of a FeBO3: Mg crystal on its magneto-optical anisotropy. Science, technology and education. 2015;4(10):15-18.

**9.** Fayziev ShSh, Juraeva LR. On the magnetic properties of iron borate doped with magnesium. Modern innovations in science and technology. 2014. P. 264-266

**10.** Dzhuraev DR, Sokolov BYu, Faiziev ShSh. Photoinduced changes inthe space-modulated magnetic order of a FeBO3:Mg single crystal. Russian Physics Journal. 2011;3(54):382-385.

**11.** Boidedaev SR, Dzhuraev DR, Sokolov BYu, Faiziev ShSh. Effect of the Transformation of the magnetic structure of a FeBO3:Mg crystal on its magnetooptical anisotropy. Optics and Spectroscopy. 2009;4(107):651-654.

**12.** Boydedaev SR, Sokolov DY, Dzhuraev D, Fayziev Sh. The ‘magnetic ripple’ state in weak ferromagnetic FeBO3:Mg. Uzbekiston Fizika Zhurnali. 2009;(5):376-383.

**13.** Fayziev ShSh. Effect of light on the modulation of the magnetic order of the FeBO3:Mg crystal. Young Science 2017;(28):8-11.

**14.** Dzhuraev DR, Fayziev Sh, Sokolov BYu. 'Magnetic ripple' in rhombohedral FeBO3:Mg crystal. Proceedings of fourth international conference dedicated to the eightieth anniversary of academician M.S. Saidov 'Fundamental and applied problems of physics'. 2010; pp. 342-344.

**15.** Valiyev UV, Saidov KS, Lukina MM. On the nature of the Faraday effect in rare earth orthoaluminate TbAlO3. Solid state physics. 1999;(11):2047-2052.

**16.** Boydedaev SR, Sokolov DY, Dzhuraev DR, Fayziev Sh. The 'magnetic ripple' state in weak ferromagnetic FeBO3:Mg. Uzbekiston Fizika Zhurnali. 2009;5:376-383.

**17.** Djuraev DR, Niyazov LN, Saidov KS, Sokolov BYu. Investigation of the spontaneous spin-flip phase transition in terbiumyttrium iron-garnet by the magnetooptic method. Ukrainian journal of physics. 2012;(5):531-537.

**18.** Dzhuraev DR, Mirzhanova N, Niyazov LN, Saidov KS. The superconductivity and nanotechnology. Modern problems of semiconductor physics. 2011, pp. 125-127

**19.** Dzhuraev DR, Niyazov LN, Saidov KS, Sokolov BYu, Khaydarova L. The spontaneous orientation phase transition in terbium-yttrium ferrite-garnet. Modern problems of semiconductor physics. 2011. pp. 76-78

**20.** Djuraev DR, Niyazov LN, Saidov KS, Sokolov BYu. Changing the cubic ferrimagnetic domain structure in temperature region of spin flip transition. Uzbekiston Fizika Zhurnali. 2011;(5):359-366.

**21.** Valiev UV, Gruber JB, Rustamov UR, Saidov KS, Sokolov VYu. A magnetooptical study of the odd crystal field component in a terbium-yttrium aluminum garnet. Technical Physics Letters. 2003;(11):882-885.

**22.** Valiev UV, Dzhuraev DR, Nekvasil V, Saidov KS. Magnetooptical studies of excited states of rare-earth ions in $Y_3Al_5O_{12}:Tb^{3+}$. Magnetic and Superconducting Materials: Volume 2. 2000. pp. 1059-1064

**23.** Fayziev Sh. Investigation of the magnetic structure of FeBO3:Mg. III international scientific conference of young researchers. 2019;(1):105-107