NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581 - 4230
VOLUME 9, ISSUE 6, June -2023

DOMAIN STRUCTURE OF IRON BORATE

Yuldasheva Nilufar Bakhtiyorovna
Doctoral student of the Department of Physics
Bukhara State University, Bukhara, UZBEKISTAN
nilufar.yuldasheva1995@mail.ru

Mavlonov Ulug'bek Mirzoqulovich
Lecturer of Department of Physics Bukhara State University
u.m.mavlonov@buxdu.uz

Abstract
Among the phase transitions from a homogeneous magnetic state to a modulated one, it is accepted to distinguish the transitions caused by the presence of a random field in the medium, which is responsible for the magnetic state of the medium, and is associated with the spatial inhomogeneity of the main interactions. Since the wave vector behavior of the modulated magnetic structure of the type reported in light planar weakly ferromagnetic $FeBO_3$:Mg and α - Fe_2O_3:Ga cannot be described within the framework of the existing thermodynamic theory of phase transitions, further research is needed to determine the physical mechanisms responsible for the modulation of the magnetic order of these crystals. is determined to be required.

Keywords: Iron borate, anisotropic crystal, ferrite, magneto-optical, modulated, polycrystalline, rhombohedral, antisymmetric, collinear, domain

Unlike antiferromagnets, where the existence of a domain structure is conditioned only by defects in the crystal lattice, in weak ferromagnets, a stable domain structure is formed due to the presence of a weak ferromagnetic moment below the Neyel temperature. Domains and domain boundaries in weak ferromagnets constitute the macroscopic domain. Therefore, their properties can be expressed in the phenomenological method using the thermodynamic potential, which is invariant to all changes of the symmetry of the crystal lattice.

Due to symmetry, iron borate-type rhombohedral crystals can have domain walls of 60, 120, and 180 degrees. The orientation of the domain walls is mainly determined by the ME energy, which is higher than the basal plane anisotropy energy and the magnetostatic energy in such crystals. It can be said that according to our calculations, if there is a crystal strain, the dominance of the ME energy can occur. The domain walls should be positioned so that magnetostriction by itself does not lead to a significant increase in the free energy. Eaton and Morrish showed that this condition is satisfied for a wall orientation such that the self-magnetostriction parallel to the domain wall is the same in neighboring domains. In the case of 180-degree boundaries, the equality of magnetostrictions is parallel to the basal plane (S1) and perpendicular to it and parallel to the plane of symmetry (SII) (Fig. 1).

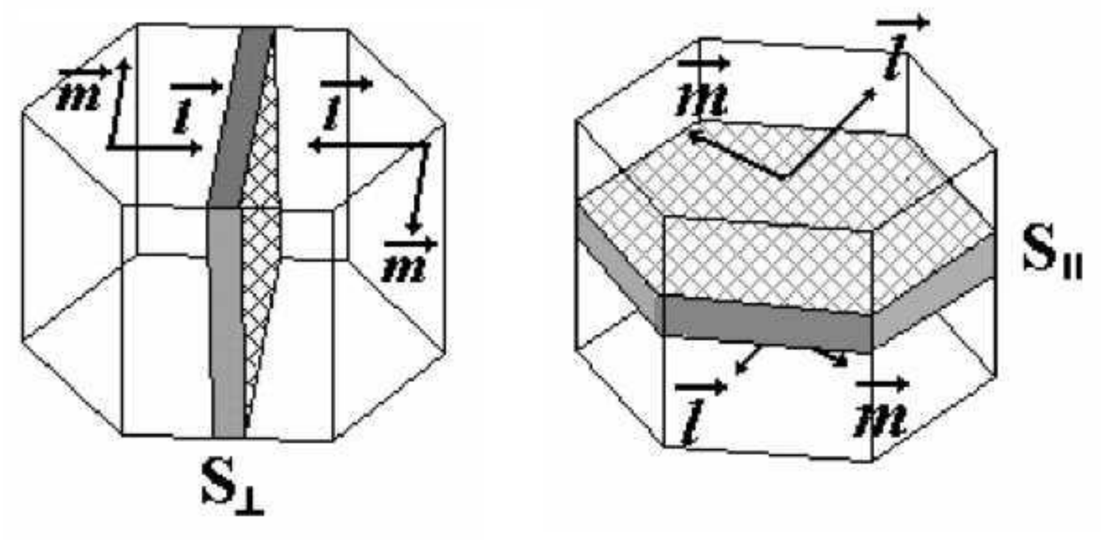


Figure 1. Domain walls of type S1 and SII.

The walls of 60 and 120 degrees should be perpendicular to the basal plane and the plane of symmetry (S1) or directed at a small angle to the basal plane parallel to the 2nd-order axis (SC, Fig. 2). This angle is determined by the elastic constants of the crystal.

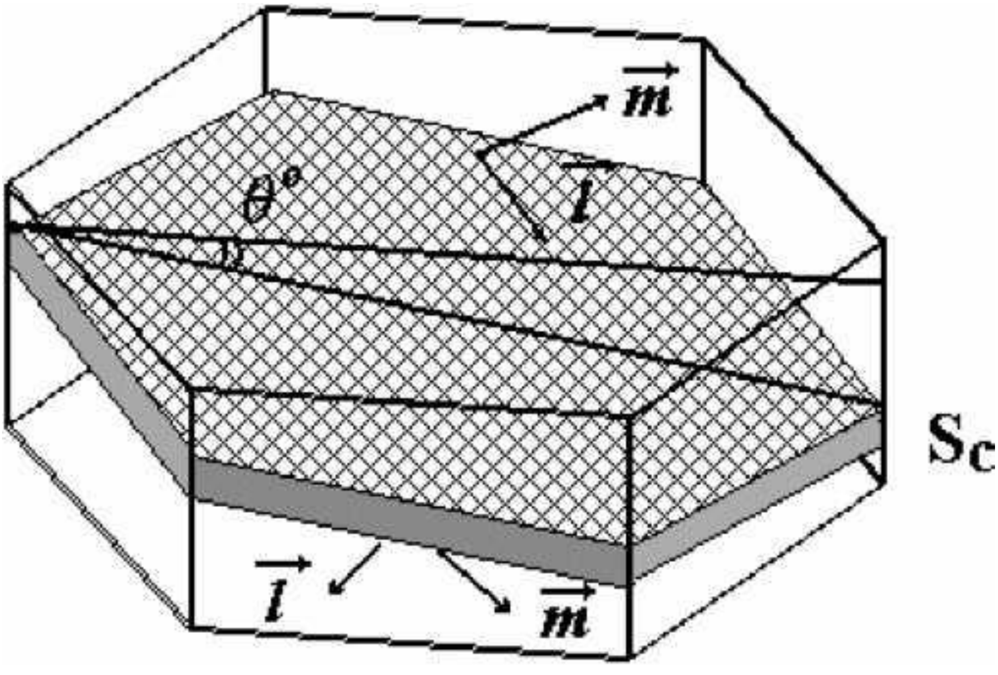
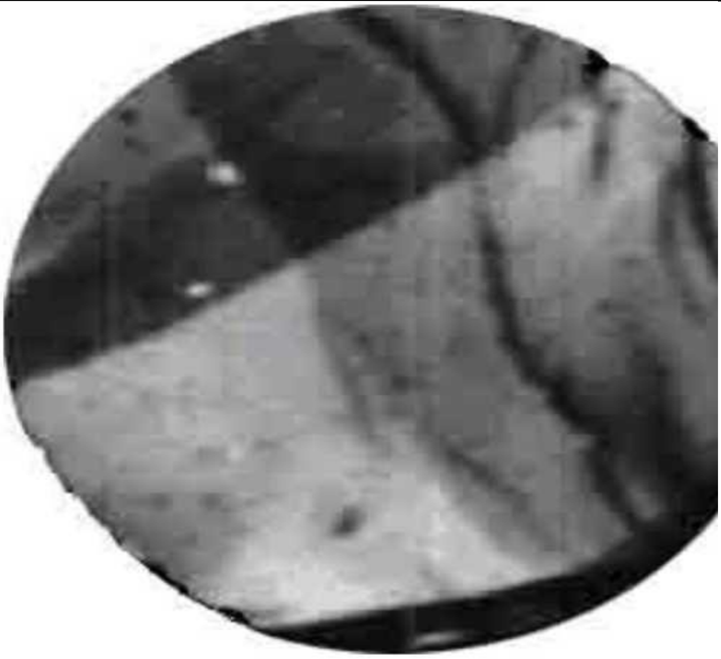


Figure 2. SC type domain wall

The domain structure of FeBO3 was studied experimentally using X-ray topography and optical interference method. In his work, Scott studied the domain structure of a single crystal of iron borate under uniaxial mechanical stress using Faraday's magneto-optical effect. Interesting results of the study of the effect of non-uniform voltages on the FeBO3 domain structure are also presented.



3-rasm. Magnit maydon yo'qligida $FeBO_3$ kristalining domen tuzilishi

Figure 3 shows a photograph in transmitted "white" light of a portion of a FeBO3 single crystal slab synthesized from a solution in solution. The crystal has a simple hexagonal shape with a side of 2.2 mm and a thickness of 50 µm. The plane of the plate corresponds to the basal plane. The central part of the visible crystal, 2.5 mm in diameter. A polarizing microscope was used to take pictures here. In this case, due to the Faraday rotation, the regions of the crystal corresponding to different areas in the photograph should have different intensities. Since the magnetization in iron borate is almost in the basal plane, the angle of incidence had to be chosen slightly different from zero to enhance the optical contrast. The presence of four regions of different intensity can be explained in terms of the domain structure model shown in Figure 3.

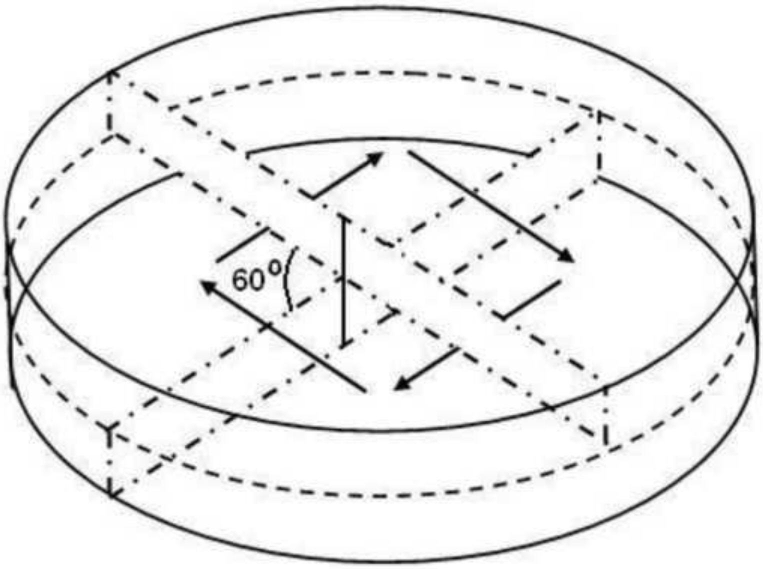


Figure 4. Distribution of magnetization in domains by crystal volume

Figure 4 shows the domain boundaries with dotted lines. There is a boundary parallel (or almost parallel) to the crystal plane, which is divided into two layers. Within each layer there are boundaries perpendicular to the crystal plane. The vectors in the figure are the magnetizations of the domains. By studying the interference boundaries in FeBO3 crystals, they concluded that the domain walls dividing the crystal into layers at temperatures below 190 K are 120-degree Bloch boundaries located at an angle of 4° to the basal plane. This result is consistent with theoretical expectations. However, due to the lack of reliable experimental data, it is not possible to say for sure whether the small slope of the 120-degree cutoff (SC) actually exists. Therefore, such a border is conventionally said to be parallel to the basal plane. Within each layer, domains are separated by 180-degree Neyelev-type boundaries perpendicular to the basal plane (S1).

The study of magnetization processes is important for understanding the structure of the domain structure of FeBO3 crystals. shows photographs of the domain structure of an iron borate crystal under increasing field applied in the basal plane at room temperature. It is clear that the domain boundaries (intersecting lines) do not interact. From this we can conclude that, as expected, they lie in different layers. The Neyelov-type S1 boundaries in the layers move, which leads to an increase in the size of the domains with the direction of magnetization close to the direction of the field. In this case, the domain walls in the upper and lower layers disappear in areas of different sizes. However, this does not mean that there is no Bloch boundary parallel to the basal plane. Visually, the change in intensity associated with the shift of the Bloch limit is not detected. However, the use of a photodetector does not allow reliable determination of the value of the loss field of the Bloch limit.

We can visualize this boundary using the powder figure (magnetic suspension) method on the natural face of a thin layer crystal, where the boundary protrudes.

Domains and domain boundaries should be located in the crystal in such a way that spontaneous magnetostriction should not lead to a significant increase in free energy. This state can be achieved when the spontaneous magnetostriction is parallel to the domain boundaries and the same in neighboring domains.

References

1. Изюмов Ю.А. Модулированные, или длиннопериодические, магнитные структуры кристаллов. // УФН. – 1984. – Т. 144. – В.3. – С. 439 – 474.

2. Звездин А.К., Пятаков А.П. Фазовые переходы и гигантский магнитоэлектрический эффект в мультиферроиках. // УФН. – 2004. – Т. 174. – №.4. – С. 465 – 470.

3. Звездин А.К., Пятаков А.П. Неоднородное магнитоэлектрическое взаимодействие в мультиферроиках и вызванные им новые физические эффекты. // УФН. – 2008. – Т. 179. – №.8. – С. 897 – 904.

4. Д.Р.Джураев, Б.Ю. Соколов, Ш.Ш.Файзиев. Структура неколлинеарной магнитной фазы ромбоэдрического кристалла $FeBO_3$:Mg. Доклады АН РУз, Ташкент, 2010, № 2, С.36-39.

5. С.Р. Бойдедаев, Д.Р.Джураев, Б.Ю. Соколов, Файзиев Ш.Ш. Состояние «магнитной ряби» в слабом ферромагнетике $FeBO_3$: Mg. // Уз.ФЖ – 2009. – В.11 (5-6). – С. 376 – 383.

6. С.Р. Бойдедаев, Д.Р.Джураев, Б.Ю. Соколов, Файзиев Ш.Ш. Влияние перестройки магнитной структуры кристалла $FeBO_3$: Mg на его магнитооптическую анизотропию. // Опт. и спектр. – 2009. – Т.107. – №2, С. 321 – 325.

7. Джураев Д.Р, Соколов Б.Ю, Файзиев Ш.Ш. Фотоиндуцированное изменение пространственной модуляции магнитного порядка монокристалла $FeBO_3$:Mg. // Известия вузов физика. 2011, -Т. 54, №2, С 201-204

8. С.Р. Бойдедаев, Б.Ю. Соколов. Индуцированный магнитным полем ориентационный фазовый переход в неоднородно напряженном монокристалле бората железа.// ФТТ. – 2009. – Т.51. – В.6. – С. 1115 – 1122.

9. Dzhuraev, D.R., Sokolov, B.Y., Faiziev, S.S. // Photoinduced changes in the space-modulated magnetic order of a FeBO3:Mg single crystal // Russian Physics Journal, 2011, 54(3), стр. 382–385

10. Boidedaev, S.R., Dzhuraev, D.R., Sokolov, B.Yu., Faiziev, S.S. // Effect of the transformation of the magnetic structure of a FeBO 3:Mg crystal on its magnetooptical anisotropy // Optics and Spectroscopy (English translation of Optika i Spektroskopiya), 2009, 107(4), стр. 651–654