

**COMPARATIVE STUDY OF THE MAGNETO-OPTICAL SPECTRA
OF WEAK FERROMAGNETS FeBO_3 AND $\alpha\text{-Fe}_2\text{O}_3$**

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Weak ferromagnets – $\alpha\text{-Fe}_2\text{O}_3$, known to the mankind during several centuries, and FeBO_3 , synthesized for the first time in 1963 by [1] attract considerable attention because of their outstanding properties including optical properties [2], and wide range of applications. Both compounds belong to the D_{3d}^6 space group and contain the same magnetic ions Fe^{3+} occupying only octahedral positions. However, they differ in the details of crystal structure such as the degree of the octahedrons distortion, the distances between neighboring magnetic ions and the angles between them, that lead to a difference in magnetic properties of the compounds. The Neel temperature of $\alpha\text{-Fe}_2\text{O}_3$ is 948 K and it becomes pure antiferromagnetic below the Morin transition at 250 K, while the Neel temperature for FeBO_3 is 348 K and it demonstrates the weak magnetic moment up to lower temperatures. Supposition was possible that the magneto-optical characteristics can be different also. Our preliminary study showed the validity of this assumption. Here we present the detail investigation of the magneto-optical properties of single crystal FeBO_3 , an assemble of nanocrystals and bulk single crystal $\alpha\text{-Fe}_2\text{O}_3$. Because of very higher optical density, measurements in the transmitted light can be realized only for the $\alpha\text{-Fe}_2\text{O}_3$ nanoparticles. The main attention was paid to the magnetic circular dichroism (MCD), that was measured for FeBO_3 in the interval 2.2-3.0 eV and for $\alpha\text{-Fe}_2\text{O}_3$ in the interval 1.2-3.5 eV for the first time. Research was supplemented by the magneto-ellipsometric measurements [3] in the reflected light.

FeBO_3 single crystals of high structural perfection of the shape of hexagonal plates up to few millimeters in the basal plane and ca. 0.01 mm in thickness have been synthesized by flux growth technique. Hematite nanoparticles were synthesized by chemical deposition from a solution. Synthesis was carried out at room temperature and constant stirring by dropwise adding an aqueous solution of ammonia (15 vol.%) to an aqueous solution of iron (III) chloride (1 wt.%). To carry out the MCD measurements, transparent composite plates containing the nanoparticles were prepared. The $\alpha\text{-Fe}_2\text{O}_3$ single-crystal was grown in the solution-melt: 79 %wt. $[\text{Bi}_2\text{O}_3 + 1.1\text{Na}_2\text{O} + 2.2\text{B}_2\text{O}_3] + 21\%$ wt. Fe_2O_3 in the temperature range from 1075-1042 °C with an increasing rate of 1-4 °C/day. Measurements was carried out for the light reflected from the (001) crystal face.

Fig. 1 demonstrates the MCD spectra measured directly for $\alpha\text{-Fe}_2\text{O}_3$ nanoparticles and calculated from the magneto-ellipsometric measurements for the single crystal $\alpha\text{-Fe}_2\text{O}_3$. It is seen that main characteristics of the spectra well coincide. For energies higher 3.5 eV measurements in transmitted light give no reliable results because of high absorption.

Several differences are seen between MCD spectra of two compounds under investigation shown in Fig. 2. In the higher energy region 2.5-3.4 eV, for FeBO_3 well resolved features are seen corresponding to the maxima observed in this crystal in [4]. At the same time for hematite, both nanoparticles and bulk crystal, MCD is presented by very wide non symmetric band. But the most significant difference between the MCD spectra of two compounds is strong S-shape feature in the $\alpha\text{-Fe}_2\text{O}_3$ spectrum at the energy interval 1.8-2.5 eV, while MCD in FeBO_3 is close to zero in this interval. This feature can be associated with an excitation of the neighboring exchange coupled iron ions so-called pair transition $2(^6A_{1g}) \rightarrow 2(^4T_{1g}(^4G))$ that was suggested by several authors to explain the feature in the $\alpha\text{-Fe}_2\text{O}_3$ absorption spectrum (e.g., [5,6]). The absence of such a band and, consequently, of the MCD features

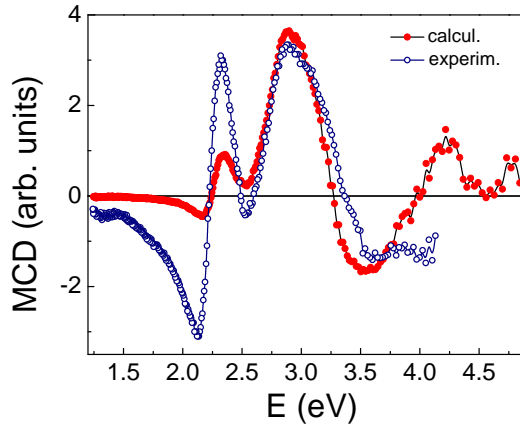


Figure 1. Room temperature MCD spectra measured for α - Fe_2O_3 nanoparticles (blue empty circles) and calculated from the ellipsometric measurements for α - Fe_2O_3 single crystal (full red circles)

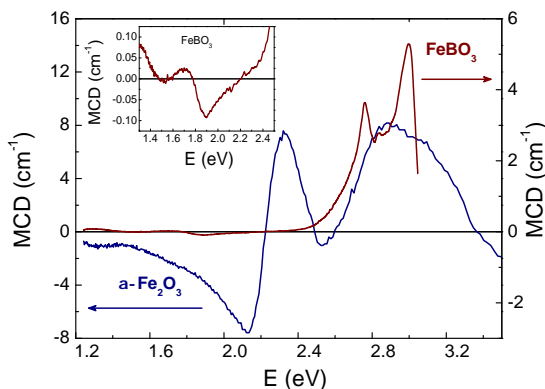


Figure 2. The MCD spectra of α - Fe_2O_3 nanoparticles (left scale) and the FeBO_3 single crystal (right scale). Insert: magnified IR part of the FeBO_3 spectrum

in FeBO_3 spectrum is explained, possibly, by the difference in exchange interactions of these two compounds. All maxima in the FeBO_3 absorption and magneto-optical spectra are associated in current literature with the one ion d-d transitions [4]. That is why, bands observed in FeBO_3 are rather narrow. The absence of the well resolved bands in the α - Fe_2O_3 spectrum in the higher energy region can be due to the contribution of other pair transition, for example, $2(^6A_{1g}) \rightarrow ({}^4T_{1g}({}^4G) + {}^4T_{2g}({}^4G))$.

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